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PNEUMONECTOMY FOLLOWED BY IMMEDIATE THORACOPLASTY

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WE RECENTLY reported three cases in which pneumonectomy and thoracoplasty had been performed at a single operation.[1] This series now includes ten patients. In this paper we should like briefly to review these cases, and to include also a few pertinent details of pre- and postoperative management as well as of technical considerations. First, however, it would seem appropriate to present those observations which prompted us to perform pneumonectomy and rather extensive thoracoplasty as a single procedure.

We all know how the encouraging early results of pulmonary resection in tuberculosis often gave way to extreme pessimism in the face of late spreads of disease in the contralateral lung following pneumonectomy, and in the ipsilateral portions of the remaining lung following lobectomy. Bronchial fistulas and tuberculous or mixed empyemas were not uncommon. Overdistention of the contralateral lung, resulting in reduced respiratory efficiency and reactivation of quiescent tuberculous foci, was particularly distressing in the pneumonectomy cases.

Improved surgical techniques and the advent of streptomycin have done much to eliminate the distressing complications of pulmonary resection in tuberculosis. In order to avoid the complications incident to overdistention of the contralateral lung, it has become routine practice in most thoracic clinics to follow pneumonectomy by one or two stages of thoracoplasty, and upper lobectomy by a single stage thoracoplasty. These operations are generally performed three to six weeks after the resection. Elective thoracoplasty, however, is not without risk. To quote Bailey and associates[2] in a recent article: "Since two of the five deaths were subsequent to elective thoracoplasties performed merely to obliterate the pleural space, it can well be imagined that we are on the lookout for a method of avoiding this secondary operation."

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Minor[3] in a recent article also stated: "When a thoracoplasty is performed over a closed pleural space containing air, or fluid, or both, a rapid increase in intrapleural pressure results. Highly positive pressure upon the heart and mediastinum produces a form of shock which may be rapidly fatal."

Our interest in pulmonary resection for tuberculosis is relatively recent, and fortunately we did not have this complication in any of our earlier cases. In a limited series, however, we did note the more benign course of postthoracoplasty resections as compared to those who had had no previous thoracoplasty. This occurred despite the increased technical difficulties which often presented themselves in a postthoracoplasty resection. There is also the problem of the patient who refuses postpneumonectomy thoracoplasty, and who, by so doing, may definitely jeopardize his future well-being.

It is beyond the scope of the present paper to discuss the indications for pulmonary resection. Obviously the main indication for resection in pulmonary tuberculosis is thoracoplasty failure, and this group is necessarily absent from this series. Seven of the combined operations here reported were performed for extensive unilateral pulmonary tuberculosis or tuberculous empyema. One was performed for pulmonary cyst and lung abscess, one for squamous bronchiogenic carcinoma, and one patient had both squamous bronchiogenic carcinoma and active pulmonary tuberculosis (Table I).

TABLE I

CASE	PATIENT	AGE (YR.)	SIDE	INDICATION FOR RESECTION
1	N. P.	33	L	Far advanced pulmonary tuberculosis
2	R. K.	21	L	Far advanced pulmonary tuberculosis
3	F. A.	51	R	Pulmonary cyst, lung abscess
4	C. R.	62	L	Far advanced pulmonary tuberculosis (preoperative diagnosis: carcinoma)
5	A. G.	48	R	Bronchiogenic carcinoma
6	J. S.	38	L	Far advanced pulmonary tuberculosis
7	C. E.	62	L	Bronchiogenic carcinoma, pulmonary tuberculosis
8	J. C.	40	R	Far advanced pulmonary tuberculosis
9	L. H.	33	R	Far advanced pulmonary tuberculosis
10	A. G.	35	L	Tuberculous empyema, pulmonary tuberculosis

TECHNIQUE

Preoperative Management.—Tuberculous patients receive streptomycin for one to two weeks, and penicillin for twenty-four hours before surgery. The usual dosage of streptomycin was ⅔ Gm daily. Premedication consisted of Nembutal gr. 1½, one and one-half hours before operation, and morphine sulfate gr. ¼ and scopolamine gr. $\frac{1}{150}$ one hour before surgery.

Position on Table, and Anesthesia.—All of these patients were operated upon in the face-down position with the sound lung uppermost, as advocated by Overholt.[4] Cyclopropane, oxygen, and ether were the anesthetic agents used. The patient was put in position on the face-down table as soon as the intratracheal tube had been placed and the course of anesthesia was proceeding smoothly. Intratracheal aspirations were carried out frequently.

The advantages of the face-down position have been enumerated by Overholt and others, but certain features deserve re-emphasis. The lessened danger of contralateral spread by gravity drainage is obvious. The ease and rapidity with which the bronchus can be exposed and occluded is also of extreme importance. It has also been our impression that patients operated upon in the face-down position show less tendency to develop shock or cardiac arrhythmias. To further combat the latter, intravenous procaine has been used prophylactically as a routine measure.

Operative Technique.—Exposure for the combined operation is obtained through a long posterolateral incision, the proximal limb being carried somewhat higher than in the usual incision for a pneumonectomy alone. As recommended by Brock,[5] we make the vertical limb of the incision close to the spinous processes. This permits both raising and closure of the trapezius and rhomboid muscles as a single layer. Blood loss also appears to be somewhat less with this incision.

The pleural cavity is entered through the periosteal bed of the sixth rib, following resection of a generous segment of this rib and the splitting of the fifth and seventh ribs paravertebrally. The intervening intercostal nerves and vessels are doubly ligated and divided. The posterior aspect of the hilus is then exposed as quickly as possible, the bronchus freed from the surrounding tissues, and a right angle clamp applied distally. Several 00 intestinal cotton sutures on an atraumatic needle are then placed high on the bronchus. These sutures are tied over the bronchial stump as the bronchus is being cut proximal to the clamp. No mattress sutures have been used in any case. This method of closure allows a high amputation and permits the stump to retract deeply into the mediastinum. In some of these cases it has been impossible to cover the bronchial stump with mediastinal pleura since complete parietal pleurectomy was performed. The pulmonary vessels are then treated in the usual manner, the artery being ligated and divided first, if possible, followed by the pulmonary veins. We have rarely used transfixion sutures distal to the proximal ligature in order to permit leaving as large a cuff as possible.

Following division of the hilar structures, the lung is freed from its remaining attachments to the chest wall and mediastinum. In so far as possible, care is taken to avoid breaking into thin-walled cavities and over these areas dissection was carried out in the endothoracic plane. This precaution particularly applied to large apical cavities. Bleeding from the raw chest wall has caused no problem since it is easily controlled by warm saline packs.

The phrenic nerve has been routinely interrupted, be it a right or left pneumonectomy.

The patient's condition is carefully evaluated at this point, and if considered satisfactory, thoracoplasty is immediately performed. In no patient have we failed to perform the thoracoplasty as planned, because of poor condition at the end of pneumonectomy. Even after such a formidable procedure as pneumonectomy, the addition of thoracoplasty did not produce shock or even an appreciable fall in blood pressure in any of these patients. It appears that performance of the additional operation at this time is not as shocking a procedure in itself as when performed over a closed and fairly rigid pleural space three to six weeks after pneumonectomy.

The usual thoracoplasty consisted of resection of the second through the seventh ribs. Generous posterior segments were removed but did not include the transverse processes. In some patients the second rib was left intact, but the intercostal structures were freed from the pleural surface and allowed to fall inward. It was our intention to preserve the normal chest and shoulder contours insofar as possible, and yet permit adequate obliteration of the pleural space.

Following thoracoplasty, the pleural cavity is thoroughly irrigated with saline and a No. 24 catheter inserted through a stab wound in the eighth intercostal space and posterior or midaxillary line. The intercostal structures, muscles, subcutaneous tissue, and skin were next approximated with interrupted cotton sutures and a lightweight but snug dressing was applied. One gram of streptomycin and 100,000 units of penicillin were instilled through the catheter, and the catheter clamped. In some of our recent cases no attempt has been made to reapproximate the intercostal structures. It is questionable whether this is a desirable procedure, and this will be elaborated upon later.

Immediate Postoperative Management.—Following completion of the operation, the patient is immediately placed on his back and the tracheobronchial tree thoroughly aspirated. In none of the cases was postoperative bronchoscopy necessary. We have abandoned the practice of routine postoperative bronchoscopy in this type of case as well as after other major thoracic operations. We feel that it unnecessarily prolongs anesthesia, and is no more effective than properly performed intratracheal aspiration with a catheter. We do not hesitate, however, to perform bronchoscopy on a patient should he remain "wet" after what is considered to be adequate intratracheal aspiration.

The anesthetic agent is discontinued during the skin closure, and a mixture of helium and oxygen administered. This mixture thoroughly removes the anesthetic agent from the lungs and facilitates the patient's early reaction after operation. The intratracheal tube is replaced by an oropharyngeal airway as soon as the patient starts to react. Nasal oxygen is started immediately. Blood is administered during the operative procedure in amounts up to 1,500 c.c. and continued after operation up to 2,000 to 2,500 c.c. A 500 c.c. transfusion was usually given on the first postoperative day. No unusual bleeding was encountered in any patient either during the operative procedure or in the postoperative period.

General Postoperative Considerations.—The same general principles apply to these patients as to others who have undergone major thoracic surgery. A few points will be emphasized.

Semi-Fowler's position and frequent turning were important to permit maximum pulmonary ventilation. Sedation in adequate amounts to control pain was necessary, and the patient was urged to cough and raise sputum at regular intervals. Coughing was greatly facilitated by having the patient sit up and apply pressure over the operated side. This could usually be started on the evening of the day of operation.

We particularly noted that these patients can cough more effectively in the early postoperative period than patients who have had pneumonectomy alone. This is attributed to the weight of the scapula and the pressure dressing over the decostalized area which render the mediastinum relatively stable.

Continuous suction of −10 cm. of water was maintained for forty-eight hours, except for a four-hour period on the first postoperative day following the instillation of 1 Gm. of streptomycin and 100,000 units of penicillin. These antibiotics were again given just before removal of the catheter on the second postoperative day.

Early ambulation is practiced and patients are urged to move about as much as possible after removal of the catheter and change of dressing on the second postoperative day. Sutures are removed on the sixth postoperative day and a pressure dressing is maintained for two to three weeks, or until the chest wall has become relatively firm.

The following case reports are presented in sufficient detail to illustrate the efficacy of the combined operation.

CASE REPORTS

CASE 1.—N. P., colored man, 33 years of age, was admitted April 16, 1948, following prolonged hospitalization at another facility. Chest film revealed extensive infiltration and multiple large cavities on the left, and infiltration in the right upper lobe. Tomography revealed a questionable small cavity in the right upper lobe, so the left pneumonectomy was deferred. Repeat tomography two months after admission failed to demonstrate any evidence of cavity in this region, and patient was prepared for surgery. Bronchoscopy revealed no evidence of significant endobronchial tuberculosis.

Streptomycin, 1 Gm. daily, was begun on July 5, 1948, and penicillin, 50,000 units every three hours, was started on July 13, 1948. After the usual preoperative preparation, left pneumonectomy and thoracoplasty were performed on July 14, 1948, in the manner described. Generous posterior segments of the second through the seventh ribs were resected. Convalescence was completely uneventful. Temperature remained normal from the ninth postoperative day and the highest temperature recorded in the postoperative period was 100.4° F. Bathroom privileges were allowed on the third postoperative day.

The wound healed per primam and excellent collapse of the left hemithorax was present. Postoperative films showed no mediastinal shift at any time and there was no evidence of contralateral spread.

The patient, in excellent general condition, was transferred back to the referring facility on Sept. 7, 1948. Sputum has remained negative by all methods of examination and pulmonary symptoms are absent. The patient has gained approximately fifteen pounds in weight and posture and arm function are excellent. He is now in a period of gradually increasing exercise preliminary to discharge.

CASE 2.—R. K., white man, aged 21 years, was admitted May 12, 1948, from another facility where he had been hospitalized since May, 1947. Admission film revealed extensive infiltration and cavitation on the left, and an essentially clear right lung. Bronchoscopy in January, 1948, had shown moderately severe tuberculous involvement of the left-stem bronchus. Streptomycin therapy in dosage of 1 Gm. daily for six weeks produced marked subjective improvement but roentgen findings persisted.

Tomography revealed cavitation in both the left upper and lower lobes, one cavity being present anteriorly in the lingular segment of the upper lobe. Total thoracoplasty was considered but resection seemed preferable. The combined procedure was recommended. It should be noted that this patient observed the postoperative course of Case 1 closely, and then also requested the procedure himself, since he bitterly disliked the prospect of multiple operations.

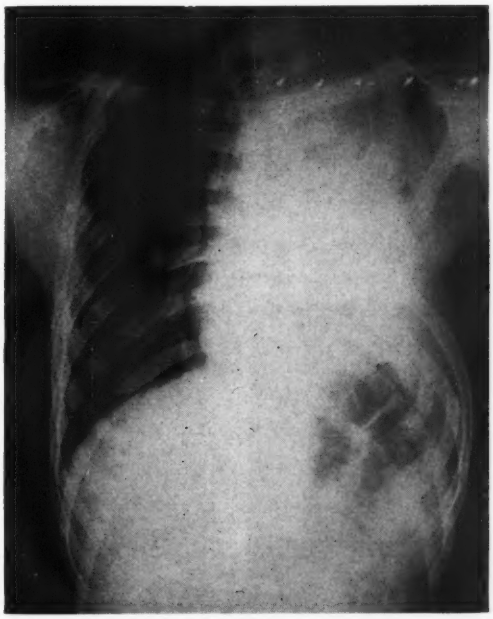

Fig. 1 (Case 2).—Postoperative combined pneumonectomy and thoracoplasty. Note that both the first and second ribs are intact.

Streptomycin, ⅔ Gm. daily, was started Aug. 19, 1948, and penicillin, 50,000 units every three hours, on Aug. 21, 1948. Left pneumonectomy and thoracoplasty were performed Sept. 1, 1948. In this patient, the first and second ribs were left in situ and the third through the seventh ribs were resected. The intercostal structures were freed from the medial aspect of the second rib and allowed to fall inward.

Postoperative management of this patient was exactly as that described and convalescence was completely uneventful. Temperature remained normal from the third postoperative day. Patient was up in a wheelchair on the second postoperative day and ambulant on the fourth postoperative day. In regard to ambulation, it must be mentioned that this patient had had a traumatic mid-thigh amputation of the left leg at the age of 6 years, and ambulation necessitated his wearing a rather cumbersome prosthesis. Cough and expectoration have been nonexistent since operation. Postoperative films showed a clear right lung and at no time any evidence of mediastinal displacement.

Fig. 2.

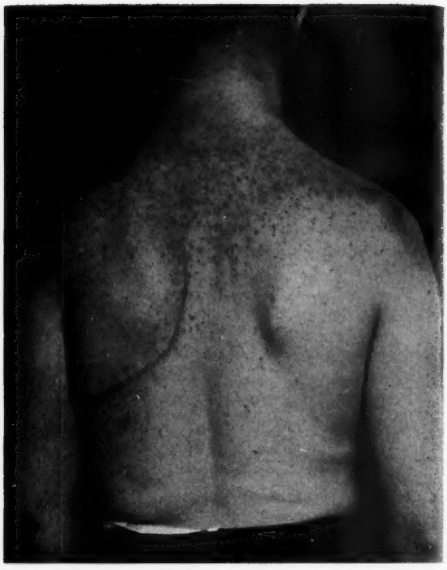

Fig. 3.

Fig. 2 (Case 2).—Postoperative appearance three weeks after combined pneumonectomy and thoracoplasty.

Fig. 3 (Case 2).—Same patient six months after operation.

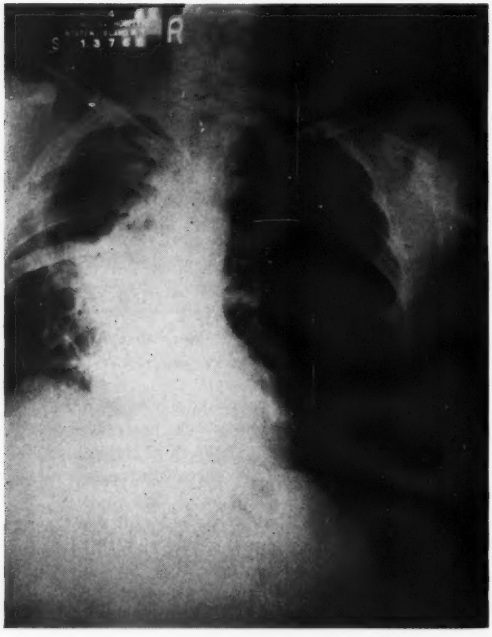

Fig. 4.

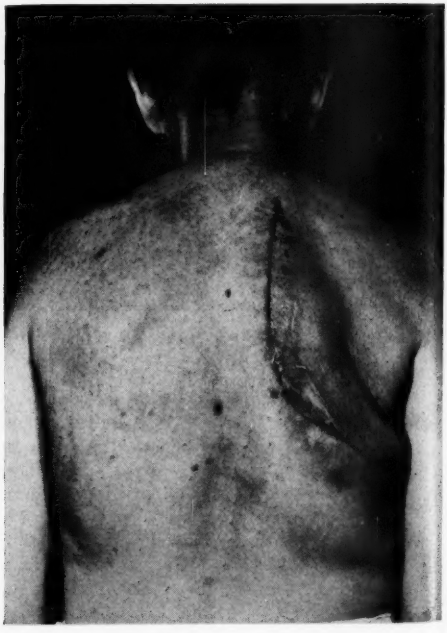

Fig. 5.

Fig. 4 (Case 3).—Preoperative film showing large right upper lobe cyst, right lower lobe abscess, and emphysema in the contralateral lung.

Fig. 5 (Case 3).—Postoperative view of patient showing minimal deformity despite resection of the second through the eighth ribs. Previous scars from abscess drainage and myoplastic closure of bronchocutaneous fistula in 1946.

This patient was discharged from the referring facility in January, 1949.

As noted in this case summary, it was decided to leave the second rib in situ in this patient because of his youth, and our desire to preserve normal arm and shoulder contours in so far as possible. This was accomplished, and at the same time adequate obliteration of the pleural space appeared to be accomplished. This patient has gained thirty-one pounds since operation, and when last seen for follow-up examination in March, 1949, the only noticeable deformity was the incisional scar.

CASE 3.—F. A., white man, 51 years of age, was admitted Aug. 3, 1948, with chief complaints of severe cough productive of 12 to 16 ounces of bloody sputum daily for three weeks, and weight loss of fifteen pounds.

There was a history of treatment in a Brooklyn hospital in 1942, for a right lower lobe abscess. He apparently completely recovered after five months' hospitalization, although chest films also revealed the presence of a large right upper lobe cyst.

His previous admission here was in October, 1946, when chest films revealed a huge right lower lobe abscess and a large right upper lobe cyst. Pneumonectomy was considered but seemed too hazardous in view of the patient's poor general condition, copious expectoration, and contralateral emphysema. Wide-open drainage was therefore instituted in November, 1946. Residual bronchopleural fistulas were closed by a pedicled muscle flap in March, 1947. Patient returned to full-time work as a crane operator in May, 1947, and remained well until three weeks before the present admission.

Chest film on the present admission revealed several small lower lobe abscess cavities and the right upper lobe cyst which showed no apparent change from previous films. The right lung was contracted and the left lung moderately emphysematous.

Patient was placed on penicillin by both intramuscular and aerosol routes with marked improvement in condition, particularly in reduction of sputum output. He was prepared for surgery and on Sept. 8, 1948, right pneumonectomy and thoracoplasty were performed. The lung was completely "frozen" to the chest wall and dissection was long and tedious. Despite this, the patient tolerated pneumonectomy extremely well, and because of the barrel type of chest, resection of long posterior segments of the second through the eighth ribs was necessary to produce satisfactory collapse.

Convalescence was uneventful. Temperature reached a high of 101.4° F. on the second postoperative day and returned to normal on the fourth day. Cough and expectoration were negligible after operation. When he was last seen for check-up examination, general condition was excellent and the only complaint was moderate dyspnea on exertion.

It would appear that in this type of case with contralateral emphysema, immediate thoracoplasty would prevent any further overdistention of the already hyperinflated lung, and thereby insure the patient's continued well-being. This case also illustrates the fact that even after a prolonged tedious pneumonectomy, the addition of thoracoplasty appears to be well tolerated.

CASE 4.—C. R., colored man, aged 62 years, was admitted on Sept. 21, 1948, following short periods of hospitalization at three different institutions since July 21, 1948. Chief complaints on admission to first hospital were pain in left chest, cough, epigastric distress, and weight loss of thirty pounds. Chest films revealed a large homogeneous density in the left mid-lung field. Sputa were negative for acid-fast bacilli. He was transferred to a second hospital where exploratory thoracotomy was performed through an anterior approach on Aug. 12, 1948. The impression was inoperable bronchiogenic carcinoma with superimposed pulmonary tuberculosis, the latter diagnosed by biopsy of a peripheral nodule. No tumor biopsy was obtained.

On admission to this hospital the findings were much as those previously noted. It was felt, however, that patient should be re-explored in view of bronchoscopic and x-ray evidence of probable operability and failure to demonstrate any metastases. Sputa examinations also continued to be negative for acid-fast bacilli. The preoperative diagnosis was bronchiogenic carcinoma.

Thoracotomy was performed through a posterolateral approach on Oct. 7, 1948. A large firm mass involving both upper and lower lobes posteriorly was found and this was densely adherent to the chest wall and aorta. The hilar structures, however, were free of nodes and tumor involvement, so left pneumonectomy was performed followed by immediate thoracoplasty as described. Again the second rib was left intact.

Convalescence was completely uneventful. Temperature remained at normal levels after the fifth postoperative day and the patient was ambulant after the second postoperative day.

The pathologic report revealed extensive caseous pulmonary tuberculosis involving about one-half of the pulmonary parenchyma. No carcinoma was found.

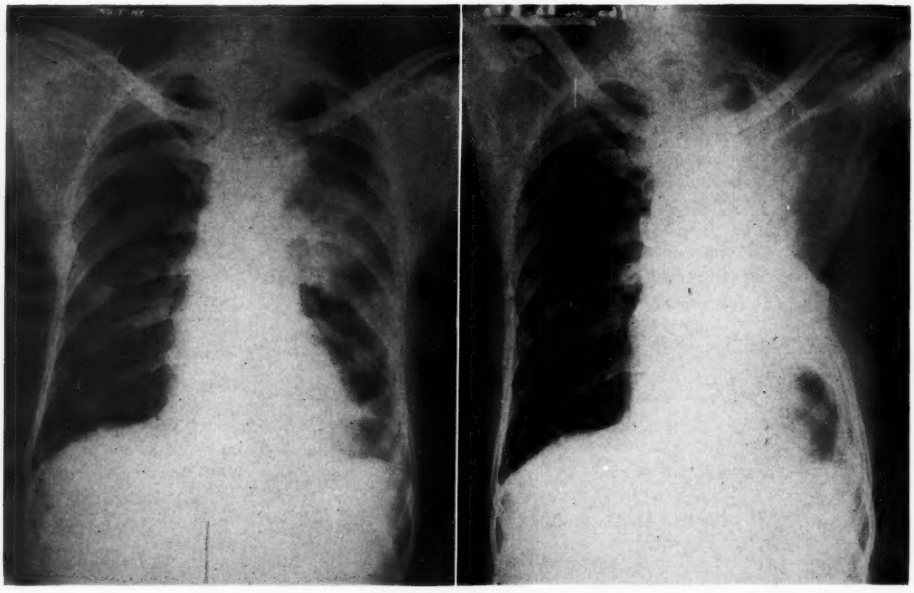

Fig. 6. Fig. 7.

Fig. 6 (Case 4).—Extensive lesion left midlung field. Had had exploratory thoracotomy at another institution with diagnosis of inoperable carcinoma and pulmonary tuberculosis.

Fig. 7 (Case 4).—Postoperative combined pneumonectomy and thoracoplasty. Note excellent collapse despite presence of the first and second ribs, the latter was stripped on its pleural surface.

This patient was returned to the referring hospital shortly after operation, and at the present time is on a program of graduated exercises preliminary to discharge. He has continued to remain well and has gained in weight and strength. Posture and arm function are excellent.

CASE 5.—A. G., white man, aged 48 years, was admitted to this hospital Sept. 18, 1948, complaining of cough and chest pain for approximately two weeks, and chills and fever for about four days prior to admission. There was a history of moderate weight loss, and also history of several episodes of hemoptyses within the few days prior to admission.

Patient was acutely ill on admission with considerable dyspnea and signs of consolidation in the right lung. Bronchoscopy on Oct. 2, 1948, revealed a tumor mass protruding from the dorsal segment of the right lower lobe and completely blocking the right middle lobe bronchus also. Biopsy revealed squamous-cell carcinoma.

On Oct. 13, 1948, a right pneumonectomy and right thoracoplasty were performed with resection of the third through the seventh ribs, and stripping of the second rib.

Immediate postoperative course in this patient was extremely satisfactory. He continued to do well for about four weeks, after which he began to run a low-grade fever. Thoracentesis yielded purulent pleural fluid. This failed to clear under antibiotic therapy and aspiration, and on Dec. 2, 1948, a tube was inserted into the pleural cavity. At no time was a bronchial fistula demonstrated. On Dec. 30, 1948, an anterolateral thoracoplasty was performed and a tube again left in place in the pleural cavity. This tube was gradually removed in the ensuing two weeks and the empyema cavity was completely obliterated. General condition continued to improve and patient was discharged on Feb. 7, 1949.

It is difficult to explain why this patient developed an empyema four weeks after the operation, except that he may have had an extremely small bronchial fistula which promptly closed spontaneously. Such a fistula, however, could never be determined even by instillation of dye. It is interesting to note that even though this empyema developed postoperatively, it was very easy to treat. In view of the fact that major collapse of the right hemithorax had already been accomplished, it was necessary only to do a small anterolateral thoracoplasty and institute tube drainage. It was plainly evident in this patient that we had not removed as long segments of rib, particularly as regards the third and fourth ribs, as on the earlier patients.

CASE 6.—J. S., colored man, aged 38 years, was admitted Nov. 4, 1948, for surgical therapy of extensive pulmonary tuberculosis of the left lung. Onset of disease was in March, 1948. From July 11 to Aug. 10, 1948, patient received 64 Gm. of streptomycin with little improvement. Admission x-ray examination at this hospital revealed extensive cavitation, thickened pleura, and possibly pleural effusion on the left. Tomography revealed no evidence of cavitation on the right. Bronchoscopy revealed no significant endobronchial disease.

After the usual preparation, left pneumonectomy and thoracoplasty were performed on Nov. 30, 1948. The lung was found to be boggy and firm in consistency throughout, and completely "frozen" to the chest wall and pericardium. Pneumonectomy necessitated complete parietal pleurectomy and partial pericardiectomy. Despite a prolonged tedious operation, thoracoplasty was immediately performed, the patient tolerating both procedures extremely well. Despite gross contamination of the pleural cavity at the time of operation (the lung literally exuded pus and there were pockets of pus between the lung and pericardium) there was no postoperative wound infection, or infection in the pleural cavity. The right lung remained clear, and sputa have been negative for tubercle bacilli by all methods since operation. His present general condition is excellent. He is gaining weight and posture and arm function are good.

This pneumonectomy was probably the most difficult technically of all the cases in this series. Removal of the lung without contamination of the pleural cavity was impossible. Here, again, despite a prolonged difficult operation, the patient tolerated the addition of thoracoplasty extremely well. It is felt that the addition of the thoracoplasty greatly enhanced his smooth postoperative course, and lessened the likelihood of wound complications.

CASE 7.—C. F., white man, aged 62 years, was admitted Nov. 16, 1948, with chief complaints of hemoptyses, cough, and weight loss. Onset of present illness dated back two years, when patient first noted cough and hemoptyses. He continued to feel well except for the hemoptyses. Chest roentgenograms were negative, and careful examination at that time for acid-fast bacilli was negative. He remained fairly well until about four months prior to admission when he first noted extremely poor appetite and beginning weight loss. Dyspnea also appeared which had not been present before.

Three weeks prior to admission bronchoscopy was done at a private hospital in Manhattan and no significant findings were noted. His physician then advised hospitalization for further observation.

Physical examination on admission revealed a chronically ill man, with evidence of considerable weight loss. There was evidence of consolidation over the left upper lobe, and this was confirmed by x-ray examination. Bronchoscopy on Nov. 18, 1948, revealed marked retraction of the left upper lobe bronchus but no tumor was seen. Bronchoscopy was repeated on Dec. 6, 1948, at which time examination with a right-angle lens revealed a tumor mass within the left upper lobe bronchus. Biopsy was obtained which revealed squamous carcinoma, grade 2. It should be noted that sputum examinations were consistently positive for acid-fast bacilli after admission to this hospital, but that the x-ray picture and clinical course were so characteristic of carcinoma that exploration was contemplated despite the persistent presence of acid-fast bacilli.

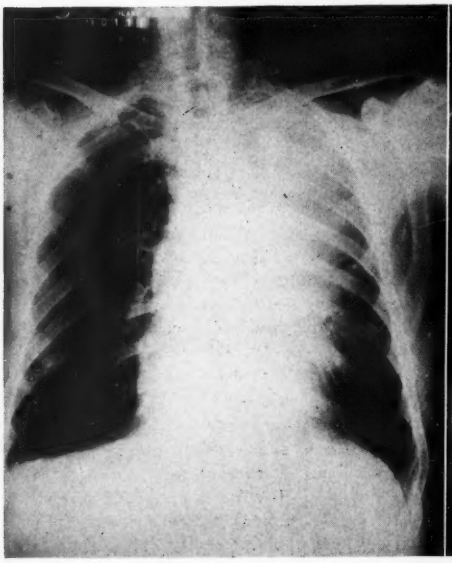

Fig. 8.

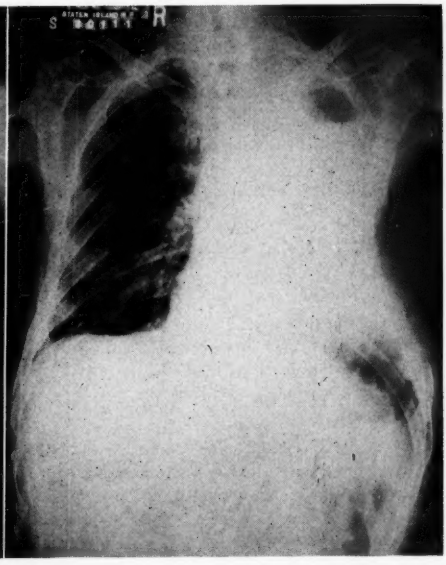

Fig. 9.

Fig. 8 (Case 7).—Preoperative film showing extensive left upper lobe lesion. Sputum positive for acid-fast bacilli. Positive bronchoscopic biopsy squamous carcinoma left upper lobe bronchus.

Fig. 9 (Case 7).—Postoperative combined pneumonectomy and thoracoplasty. Small amount of fluid still present in residual pleural space.

After the usual preoperative preparation, thoracotomy was performed on Dec. 21, 1948. The tumor mass encroached upon the hilar region, particularly in the superior pulmonary vein, but intrapericardial ligation of this vessel greatly facilitated removal. Several nodes were removed from the mediastinum and subaortic region, which appeared to be involved in carcinoma. The wall of the bronchus also appeared to be involved, almost up to the carina, and an extremely high amputation was necessary. Bronchial closure was extremely difficult and was not as satisfactory as desired. For this reason it was decided to perform a thoracoplasty, immediately, in the hope of lessening any probable postoperative pleural complications. To secure adequate collapse, generous posterior segments of the third through the eighth ribs were resected and the second rib was stripped on its medial surface. The intercostal structures were then allowed to fall directly over the mediastinum and no attempt was made to approximate the upper and lower flaps.

Postoperatively this patient did extremely well. He was ambulant after removal of the tube on the second postoperative day, and the highest postoperative temperature was 99° F. His present condition is excellent, he is gaining in weight and strength, and

sputa have remained negative for acid-fast bacilli. He is now on a program of increasing activity at the sanitorium where he was transferred following operation. Prolonged convalescence because of the tuberculosis is not indicated, since the pathologic report revealed the hilar nodes to be involved with tumor, making his ultimate prognosis poor.

It would appear that we were extremely radical in performing an extensive thoracoplasty on a patient with carcinoma who was not in the best physical condition. However, the bronchial closure in this patient did not appear to be satisfactory, and could not be made so because it was amputated extremely high and the tissues appeared to be friable from chronic inflammation. Even in this elderly patient, posture and arm function following this procedure are excellent.

Fig. 10 (Case 7).—Postoperative view of patient showing excellent arm and shoulder function.

CASE 8.—J. C., colored man, aged 40 years, was admitted Jan. 18, 1949. There was a history of being well until April, 1948, at which time he experienced generalized malaise, weight loss, and developed a productive cough, later associated with hemoptyses. He was hospitalized at another facility where x-ray examination revealed extensive tuberculosis involving the right lung. Right pneumothorax was attempted without success.

Chest film and tomography on admission revealed multiple cavities in the right upper lobe and extensive consolidation and questionable cavitation in the lower lobe. Bronchoscopy revealed endobronchial disease involving the right upper lobe bronchus.

Following preliminary streptomycin therapy, right pneumonectomy and right thoracoplasty were performed on Feb. 3, 1949. Complete extrapleural dissection was necessary over the entire upper half of the lung. Following pneumonectomy, a thoracoplasty was performed, with resection of the third through the seventh ribs; the second rib was stripped medially, and the intercostal structures allowed to fall inward. Here again no attempt was made to approximate the intercostal structures. Operation was completed in the usual fashion and patient withstood both procedures extremely well.

This man's convalescence has been considerably more stormy than the previous patients, with chief complaint being dyspnea. No significant shift of the mediastinum has been observed on any films and the left lung has shown no evidence of spread. How-

ever, he has continued to require the occasional use of nasal oxygen, particularly at night. He has been afebrile since shortly after operation, and aspirated specimens from the right pleural cavity have failed to reveal any evidence of growth, either acid-fast bacilli or secondary organisms. His general condition has remained good and it is felt that this patient will eventually make a good recovery despite the dyspnea now present. It is probable that bronchospirometric determinations prior to operation in this patient would have revealed considerably more loss of function in the so-called good lung, than was estimated prior to surgery.

CASE 9.—L. H., white man, aged 33 years, was admitted Jan. 13, 1949. There was a history of pulmonary symptoms since January, 1947, but patient did not seek medical attention until the spring of 1948, when progressive weakness, hemoptyses, and marked weight loss occurred. He was hospitalized at another facility where x-ray examinations revealed bilateral infiltrations with multiple cavities in the right upper lobe and probably in the apex of the right lower lobe. Right pneumothorax was initiated in May, 1948, followed by right pneumonolysis in June, 1948. Despite a complete pneumonolysis and excellent collapse of the right lung, cavities failed to close. In addition, the patient was extremely uncooperative and left the hospital against advice, after a few months. He was admitted to another hospital in August, 1948, where pneumothorax was continued, and despite a fairly stable clinical course, patient failed to convert sputum, and cavities were still evident.

Examination on admission revealed a chronically ill white man, in no obvious distress. Rather extreme collapse of the right lung was present, but cavities were evident even on plain films and tomography revealed multiple cavitations in the collapsed lung. Sputum was positive for acid-fast bacilli. Bronchoscopy on Jan. 19, 1949, revealed no evidence of active tuberculous ulceration but there was some narrowing noted in the orifice to the right middle lobe, which was interpreted to be due to a healed tuberculous process. The right pneumothorax showed no tendency to re-expand.

On Feb. 16, 1949, right pneumonectomy and thoracoplasty were performed in the manner described, with removal of the second through the seventh ribs. The intercostal structures were loosely sutured against the posterior chest wall, but were not approximated at the site of the rib resection.

Postoperative management was similar to cases previously described. The immediate course was extremely satisfactory, but two weeks after operation the patient developed signs of a bronchial fistula and coughed up clear serous material from the right pleural cavity. On March 3, 1949, through an anterolateral incision, anterior segments of the second through the fifth ribs were resected, and the pleural cavity opened through the periosteal bed of the third rib. The residual pleural cavity was found to be small, was covered with clean granulations, and contained a small amount of clotted fibrin and a small amount of amber fluid. Despite the previously noted clinical presence of a bronchial fistula, there was no visible evidence of one even on careful examination. Resuture of the bronchus seemed impossible since it had retracted so deeply into the mediastinum. A No. 24 catheter was inserted and brought out through a stab wound anteriorly. The wound was closed in the usual fashion and a pressure dressing applied. Convalescence from this procedure has been extremely satisfactory, and cough and expectoration have progressively decreased until at the present the amount of sputum raised is minimal. Sputum has continued to be negative for acid-fast bacilli since operation, and it is anticipated that the catheter can be removed completely in the next two to three weeks.

CASE 10.—A. G., white man, aged 35 years, was admitted Jan. 10, 1949. There was a history of tuberculosis since January, 1938. In 1939, he had a small upper-stage thoracoplasty, and for reasons known only to the doctor under whose care he was at that time, pneumothorax was instituted following the first-stage of thoracoplasty, and further operations abandoned. Pneumothorax was apparently successful and patient returned to work in 1940, continuing the pneumothorax on an outpatient status. He felt well until November, 1948, when he developed weakness, exertional dyspnea, and cough. The pleural cavity was aspirated by a private physician, and the patient later noticed that he coughed up

the same type of material which was aspirated from the pleural cavity. General condition became progressively worse, appetite decreased, weight dropped approximately sixteen pounds, and he noted daily temperature elevations.

On admission to this hospital x-ray examination revealed an extreme collapse of the left lung and the pleural cavity filled with fluid. Aspiration yielded grossly purulent fluid which was highly positive for acid-fast bacilli. Sputa examinations were persistently positive for tubercle bacilli.

Tomography failed to reveal evidence of cavitation in the right lung and after preliminary streptomycin therapy, left pneumonectomy and left thoracoplasty were performed on March 14, 1949. Convalescence to date has been extremely satisfactory, although it is as yet too early to make any final predictions.

SUMMARY

Ten patients who have undergone total pneumonectomy and rather extensive thoracoplasty at a single operation, have been presented, together with a brief description of the operative procedure and a few pertinent details of pre- and postoperative management. It would appear that this combined procedure has its chief advantage in the patients with pulmonary tuberculosis requiring pneumonectomy, in whom overdistention of the contralateral lung is particularly undesirable. We have extended indications for the procedure to include other patients in whom it would appear desirable to follow pneumonectomy with a thoracoplasty, in particular those with contralateral emphysema or those patients in whom postoperative pleural complications might be expected.

Our experience seems to indicate that the thoracoplasty may safely be performed upon completion of the pneumonectomy, if proper attention is given to supportive therapy and certain operative details. The necessity for only one operation and the lessened hospital stay are particularly desirable.

Although we did have one bronchial fistula occurring in this series, it would appear, theoretically at least, that prompt obliteration of the pleural space should greatly lessen the dangers of bronchial fistula and empyema, both as to their incidence and their treatment, should they occur.

Our observations of these cases also seem to indicate that disturbances in respiratory physiology are less marked than after pneumonectomy which is not followed by thoracoplasty. Decostalization of the chest wall of sufficient degree to permit the scapula to fall inward and the supplementing of this with a pressure dressing appears to render the mediastinum relatively stable. By the same token the coughing mechanism of the patients in the immediate postoperative period appears to be enhanced.

The posture and arm function of these patients appears to be surprisingly good. In patients who have gained weight following the procedure, little deformity is present.

There has been no mortality in any of the patients upon whom this combined procedure has been used.

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DISCUSSION

DR. CARL SEMB, Oslo.—Mr. President, members of the Society, and guests: First I wish to thank Dr. Churchill for his kind invitation to attend this meeting and speak on an old subject, experiences with 1,000 cases of pulmonary tuberculosis treated by thoracoplasty with extrafascial apicolysis.

The principle of this operation is relaxation of the lung so that the pathologic part can contract concentrically toward the hilum in all three planes. Because of the apicolysis, the foremost parts of the resected ribs can be spared and the functionally important lung tissue as well.

This represents an advantage over thoracoplasty without apicolysis, where considerably more of the ribs must be resected to accomplish a similar collapse, if that is possible. The apicolysis has become more radical, medially in the mediastinum, as a rule to the hilum, past the arch of the aorta on the left side, and to the azygos vein on the right. In the first stage where, as a rule, only the first three ribs are resected, the lung is loosened in a "pocket" posteriorly and downward below the nonresected rib. In the next stage the periosteum and intercostal bundles of the ribs which have been resected, are transected, for example, the fourth, fifth, and sixth, and the apicolysis is enlarged correspondingly.

In the postoperative treatment it is important to maintain the size of the apicolysis cavity until the lung is well contracted and until bone has regenerated from the periosteal beds of the resected ribs. This space is filled with saline, blood, air, oil, or fibrin foam. In the fibrous and "stiff" cases an infolding suture can be placed over the apex to increase the collapse. This development in operative technique has made possible a reduction in the number of ribs resected, as well as in the length of resection of each rib. A six-rib thoracoplasty and less now make up about 75 per cent of the total number performed; only 5 per cent have a total collapse. Thoracoplasty with apicolysis has, in short, become a small operation. From a cosmetic point of view there is practically no deformity following operation.

Our patients operated on between 1935 and 1941 have been examined over a period of more than three years and up to eight years. Cases are accurately followed-up by the health department and sanatoria physicians, planigrams being taken in doubtful cases and great numbers of cultures. The collected data in 401 cases show the following: mortality, 4.5 per cent; late mortality, after three years or more, 12.7 per cent. Of the surviving 82.8 per cent, nearly all were cured; almost 80 per cent of the total series were cavity and bacilli free.

A large series includes many varying factors and is thus difficult to evaluate. The material is therefore divided according to cavity size: Small cavities are those up to 2.5 cm. in diameter; middle-sized, up to 4 cm. in diameter; large, up to 5 cm. in diameter; and giant, greater than 5 cm. in diameter. The results vary in accordance with the size of the cavity. The operative mortality increases from zero in small cavities to nearly 15 per cent in giant cavities. The late mortality increases in a similar fashion. The final cures decrease from about 95 per cent in small cavities to 50 per cent in giant cavities.

The series is also divided according to the phase of the disease determined after an observation period in the sanitorium, as predominantly productive, predominantly fibrous, predominantly mixed, or predominantly exudative phases. The operative and late mortality and the final results are most favorable in the productive phase, and relatively unsatisfactory in exudative lesions.

The demonstrable difference in the groups indicates the rationale for such division of material in making comparisons with other forms of treatment.

As mentioned before, small thoracoplasties play a steadily increasing role. In a group of 174 patients upon whom three-, four-, and five-rib thoracoplasties were carried out between 1942 and 1948, the results have been as follows (five were bilateral thoracoplasties, 261 stages):

Temporary infection as a complication occurred in 2 per cent; an appreciable number of these cases were, however, before penicillin and streptomycin were available; no permanent fistula followed the infection.

Mortality in the first two postoperative months was 1.7 per cent; later mortality, 3.5 per cent. In the follow-up studies over a period of seven years after operation, 88.5 per cent are without cavity and have negative sputum. A number of these patients have not been followed sufficiently long for evaluation of permanent results, but these figures give an idea of the relatively safe and, for the present, good results of the small thoracoplasty.

The question of tuberculous empyema is correlated with treatment of pulmonary tuberculosis as a whole. In our material 85 per cent of such cases have demonstrated active pulmonary disease in need of collapse. Fifty per cent have mixed infection.

Time plays a major role in regard to prognosis and treatment. Surgery has the greatest chance during the first period when the general condition of the patient is still relatively good, and before the empyema cavity has become too stiff-walled. Operative technique aims at collapse of the empyema cavity and at the disease itself. The cavity is usually located upward and backward. From a purely mechanical standpoint it is, in my opinion, necessary to do a radical apicolysis and pneumonolysis to close the cavity superiorly and posteriorly, especially if it can be done with a moderate rib resection. The empyema cavity is drained of air and pus during operation by means of aspiration through the pleura.

A local thoracoplasty may be sufficient to cure a total or subtotal empyema. After the operation the bronchial fistula and cavity can be closed, the pus becomes thinner and decreases rapidly with aspiration, the remaining part of the lung re-expands and can regain function.

One case is demonstrated: a subtotal empyema with bronchial fistula and cavity on the opposite side. A five-rib thoracoplasty was performed on the right side with closure of the bronchial fistula and re-expansion of the lower lobe. There was increase of the left side cavity, and local thoracoplasty in two stages was done with resection of five ribs and closure of that cavity. The patient is now free of empyema, has negative sputum, relatively good lung function, and is working.

Our experience over a seventeen-year period with about 1,000 cases of thoracoplasty with extrafascial apicolysis can be thus summarized: Development of the operation's effectiveness and selectivity, minimal complications and mortality, maintenance of relatively good lung function have, in our experience, given the procedure a prominent position with relation to pneumothorax, extrapleural pneumonolysis and resection.

DR. PAUL W. SANGER, Charlotte, N. C.—I agree that there are certain cases in which it is desirable to collapse the thoracic cavity with resection of the lung. Past experience has shown that it is much easier to resect the lung after the thoracoplasty has been done, so in the few cases that we have resected the lung and collapsed the thoracic cavity in one sitting, we have performed the thoracoplasty first; it is thereby much easier on the surgeon and, I think, on the patient as well.

DR. ROLLIN A. DANIEL, Nashville.—The most serious complication we have had following pneumonectomy for tuberculosis is infection of the pleural cavity. This complication we can divide into two groups as regards time following total pneumonectomy. Several patients have had empyema with or without bronchopleural fistula within a period of five or six weeks following operation. During the last several months, however, we have had two patients return to us with empyema, one with bronchopleural fistula and widespread infection in the opposite lung, two years and two years and eleven months following pneumonectomy. In each of these patients partial thoracoplasty had been carried

out several weeks following pneumonectomy. We believe now that thoracoplasty not only should be done early but that it should be more complete than the operation we have carried out previously. We feel that the first rib should be removed and that, although it probably is not necessary to remove the transverse vertebral processes, the procedure should be carried down low enough to accomplish complete obliteration of the pleural cavity on that side.

DR. CARL SEMB, Oslo.—Taking advantage of being now a member of the Association, I should like to mention something about the combination of resection and thoracoplasty. From a theoretic point of view, as has been pointed out by others today, it is of great importance to perform a thoracoplasty to reduce the thoracic cage according to the resected part of the lung; the remaining part of the lung should not be distended. Thus in a prolonged resection and a prolonged thoracoplasty on the lower lobe we may do it with a phrenic nerve avulsion or with total resection and total thoracoplasty.

I have usually started with thoracoplasty in cases of tuberculosis because of the efficiency of the thoracoplasty under different conditions; especially where there are indications for lung resection with bronchiectasis we have, as Dr. Sanger pointed out, a very good effect with thoracoplasty if there is a total bronchiectasis. If we start with thoracoplasty we have the chance of being able to cure, or nearly cure, the patient without doing resection of the lobe or the lung afterward. When we have started with thoracoplasty, this does not usually cause difficulties so far as later resection of the lung is concerned, and it is not much more difficult than usual. The main indication for thoracoplasty is, I think, in such cases to start with thoracoplasty and afterward do a resection.

DR. SKINNER (closing).—I wish to thank the members for discussion of this presentation. I would like to emphasize two points, first, this procedure is not quite so formidable as it may at first appear. In none of these cases have we incurred any degree of shock following the thoracoplasty procedure. Of course in all these patients a careful review has to be taken with the anesthetist to evaluate their condition before proceeding with the thoracoplasty. I might say that three of the patients were not particularly good risks; they had massive empyema and complete extrapleural dissection was necessary, which was quite long and tedious; in one the operation lasted more than five hours. But as a rule thoracoplasty does not take more than 20 to 30 minutes. The other point I would like to make is concerning the care of complications. One patient had a bronchopleural fistula and one had an empyema pocket. The ease with which these were handled and the very little discomfort to the patient, if compared to a case without thoracoplasty, is a remarkable thing; either one could have been of major consequence. So we feel that is one advantage of the procedure.

FUNNEL CHEST AND ALLIED DEFORMITIES OF THE THORACIC CAGE

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NEW YORK, N. Y.

FUNNEL chest is not a particularly uncommon deformity and a definite number of those displaying it are severely incapacitated by it. There is a considerable literature on the subject dating back to the sixteenth century, admirably reviewed by Ochsner and DeBakey[1] in reporting a case. The etiology was obscure and the surgical treatment unsatisfactory, however, until Brown[2] recognized a short central tendon of the diaphragm as the cause of the deformity and described a surgical method for its correction. During the past five years we have seen a great many of these cases and have operated upon 31 of the patients.

The deformity is produced by a short central tendon of the diaphragm which flattens the dome of the relaxed muscle so that when the muscle contracts during inspiration the lower end of the sternum, to which the diaphragm attaches, is drawn backward causing, in time, a funnel-shaped deformity of the chest wall whose apex is at the xiphoid. The deformity may be symmetrical or asymmetrical and its character is determined by the portion of the central tendon which is shortest (Figs. 1 and 2). It may be considered under three heads: first, that produced by the direct pull of the diaphragm on the xiphoid and costal arch; second, that which appears elsewhere on the thoracic cage as a result of this pull; and third, the abnormalities of the organs within the chest as a result of the deformity of the thoracic cage.

When the mid-portion of the central tendon is shortest the xiphoid and lower end of the sternum will be retracted so that the sternum curves backward from the second segment to the xiphoid, where the depression is greatest. The costal cartilages are also drawn backward by the retraction of the sternum. This applies not only to the single cartilages but also to the fused cartilages forming the costal arch. The result will be a symmetrical funnel (Fig. 3).

If the diaphragm is short in the lateral leaflets as well as in the mid-portion of the tendon there will be a direct pull on the costal arch as well as on the xiphoid, and in addition to the funnel there will be a transverse groove across the anterior chest wall below the xiphoid. This resembles the Harrison's groove of rickets, although rickets has nothing whatever to do with funnel chest (Fig. 4).

If one lateral leaf of the diaphragm is shorter than the other the deformity will be asymmetrical with the maximum depression on the side of the greater shortening. This will cant the sternum toward that side as well as retract its lower end (Fig. 5).

If the shortening is in the lateral leaflets and not in the mid-portion of the central tendon there will be a groove without a funnel and it will be unilateral or bilateral depending on whether one side or both are short (Fig. 6).

Read at the Twenty-ninth Annual Meeting of The American Association for Thoracic Surgery, New Orleans, La., March 29-31, 1949.

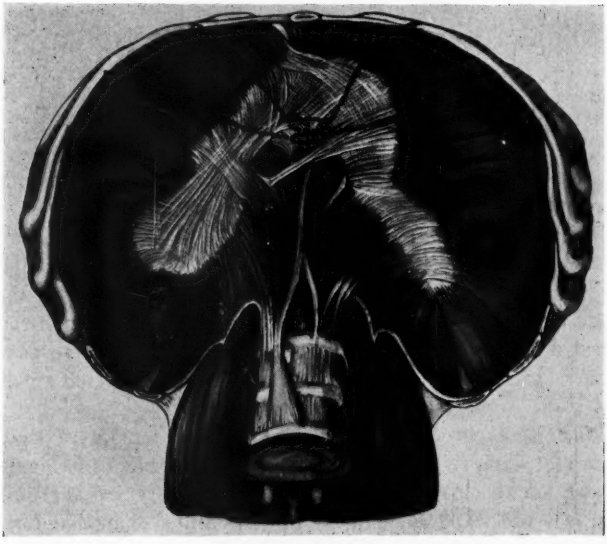


Fig. 1.—Diagrammatic sketch of diaphragm in normal position. First broken line indicates position of sternum with shortening of mid-portion of tendon only. Second broken line indicates position when lateral leaflets are also shortened.

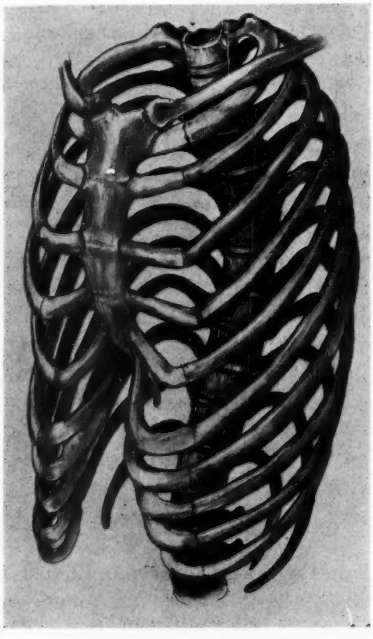
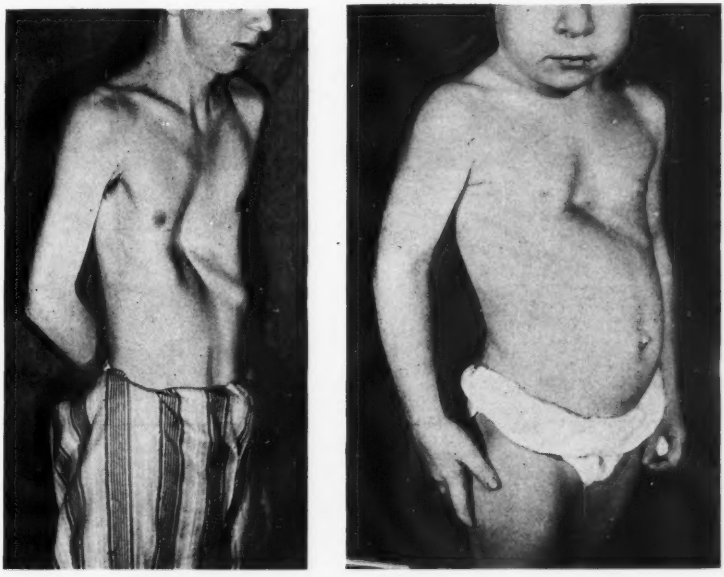


Fig. 2.—Diagrammatic sketch of bony thorax showing deformity produced by shortening of central tendon of diaphragm.

The second class of deformity is that resulting from the alteration of the ribs and vertebral column because of the funnel sternum. The pull of the diaphragm seems to exaggerate the normal curve of the dorsal spine giving the individual a round-shouldered appearance and also making the funnel seem deeper. In addition the downward slant of the ribs is increased, thus making a long and narrow chest with diminution of both the anteroposterior and lateral diameters (Fig. 7). This gives a characteristic appearance to the roentgenogram and is an important consideration in predicting the result of corrective surgery.

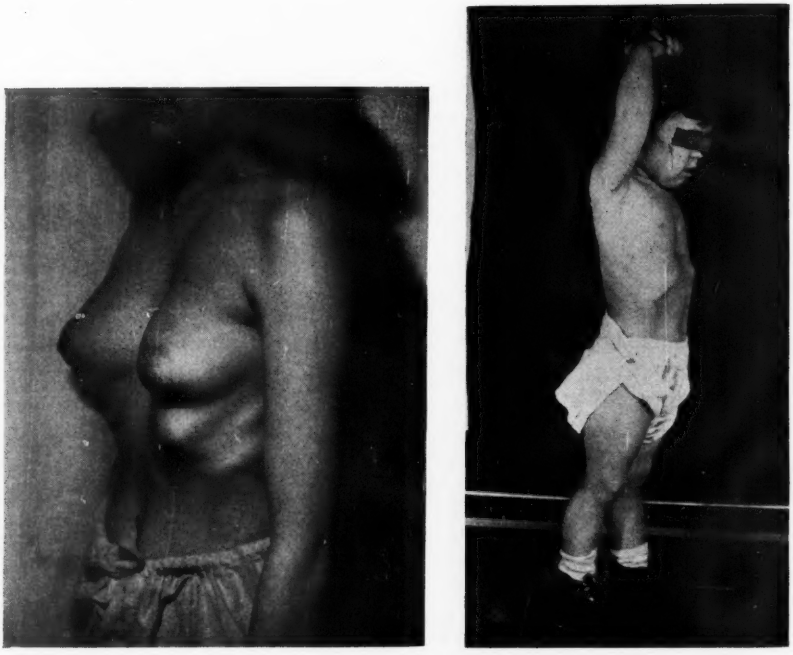
The structural changes in the bony thorax can be expected to produce some effect on the thoracic organs. The lung is somewhat compressed but this is a minor disturbance and seldom amounts to more than 25 per cent reduction of the lung volume. It may also be distorted and it is possible that the respiratory infections to which these patients are unduly susceptible may be explained on the basis of defective bronchial drainage due to this distortion. The breathing is paradoxical to the extent that the lower end of the sternum and costal arch are retracted backward during inspiration and move outward during exhalation.



A. *B.*

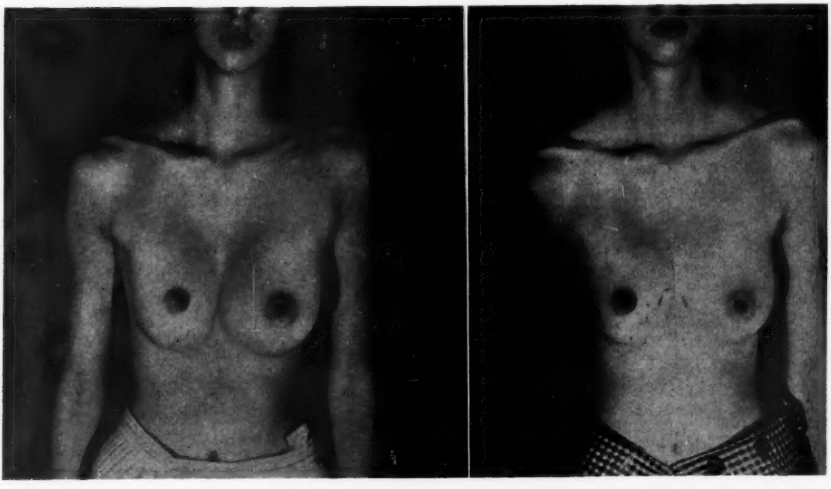
Fig. 3.—*A*, Funnel chest in boy 19 years of age. *B*, Funnel chest in girl 3 years of age.

The heart is the organ most effected by the deformity. It is displaced to the left, often to such an extent that the apex is in the axilla, and is also compressed. This compression interferes with the dilation of the heart necessary to accommodate the increased blood flow associated with muscular activity and hence may have a profound effect on the patient's exercise tolerance. Dyspnea associated with funnel chest is due to cardiac restriction and not pulmonary



A. *B.*

Fig. 4.—*A*, Well-developed transverse groove in funnel chest deformity in girl 15 years of age. *B*, Early transverse groove in funnel chest in girl 2 years of age.



A. *B.*

Fig. 5, *A* and *B*.—Asymmetrical deformity of funnel chest producing apparent underdevelopment of right breast, corrected by operation.

compression. A systolic murmur is also common and many of these patients are treated for cardiac disease which does not exist. Electrocardiographic changes are usual but their significance is not understood and they are now the subject of investigation.

Obviously a deformity of this sort will alter the appearance of the breasts in the postadolescent female. If the deformity is symmetrical the breasts may seem larger because of the deepening of the groove between them. If the deformity is asymmetrical one breast will be in a depression and hence will appear smaller (Fig. 5). In two cases of this sort the depressed breast was actually smaller and its elevation to the level of the other breast did not entirely satisfy the owner although it did materially decrease the deformity.

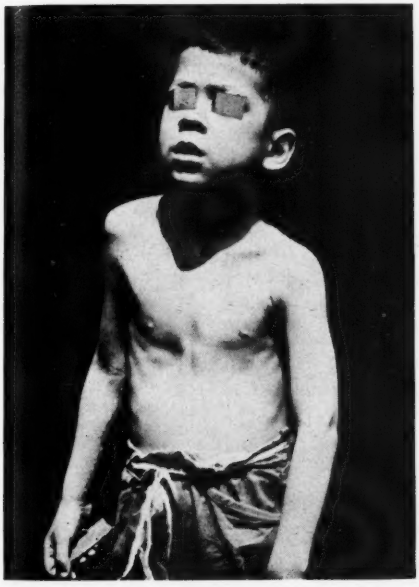


Fig. 6.

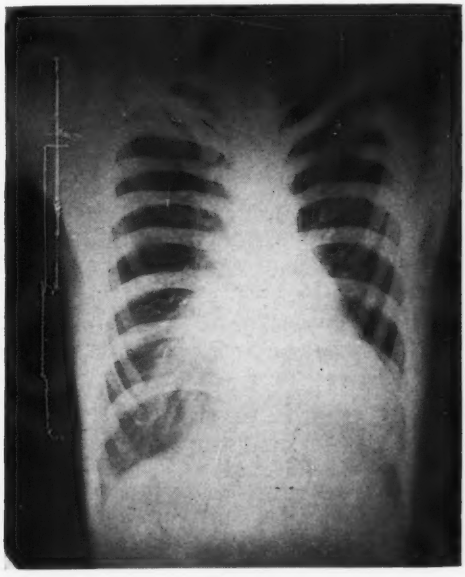


Fig. 7.

Fig. 6.—Transverse groove without funnel chest depression in boy 4 years of age.

Fig. 7.—Roentgenogram of chest showing abnormal downward slant of ribs, narrowing of thorax, increased bronchial markings, and displacement of heart.

Nearly all the patients with obvious funnel chest are also underweight. This, together with the round-shouldered, narrow-chested, and funnel-chested appearance of the individual, gives him anything but a robust figure. The deformity is least at birth and increases with the growth of the child. It first affects the lower sternum and adjacent cartilages but sooner or later involves the ribs and vertebrae to produce distortion of the bony cage. Therefore, the time to correct the deformity is before it involves bony structures other than the sternum and thus becomes irreversible.

The indications for operation are physiological and psychological. In the extreme case with greatly limited activity and defective physical development there can be no question as to the advisability of operation. When the exercise

tolerance is only moderately decreased, operation is also indicated. If the deformity is first noted in infancy and does not decrease with age, or becomes more pronounced, surgical interference is still advisable to prevent an irreversible deformity. Furthermore, although there is no apparent decrease in the exercise tolerance before operation, because the patient has never known anything different, he will realize after operation that a limitation did exist because he can then exercise more. The patient with moderate deformity without functional disturbance will not be benefited by operation except for psychological reasons.

The psychological aspect of the situation is of great significance. The girls do not pay much attention to the deformity until their breasts begin to develop and they start to wear a brassiere. Then they become conscious of it. The boys notice their deformity earlier probably because they run around unclad with other boys who take delight in calling attention to any deformity with derisive language. Many children take this teasing without trouble but others cannot and they are entitled to a corrective operation.

The operative procedures have been described by Brown[2] and we[3] have reported on our modification of them. A simple operation to be used on infants consists in separating the xiphoid from the sternum and allowing the diaphragm to pull it back. This is done through a longitudinal incision over the lower end of the sternum and adjacent abdomen. The xiphoid is hidden by the cartilages of the costal arch which are drawn together by the deformity and it is necessary to resect the apex of the arch to expose it. The xiphoid is then detached from the sternum by a transverse incision which enters the ventral mediastinum and thus severs the substernal ligament, a prolongation of the linea alba along the under surface of the sternum. The diaphragmatic attachments to the arch in the immediate vicinity are then pushed off and the wound closed.

The radical operation must be used in all instances where the deformity is established and that will probably be in all patients more than 16 months old. The procedure we now use has been developed by a process of trial and error. Since the costal cartilages below the second are responsible for the deformity as well as the sternum, they must be resected laterally to the point at which the backward curve commences. The cartilages of the costal arch must also be resected to the point at which the backward curve commences and far enough to take in the lower border of the transverse groove, if this exists, that is, to include the third to the eighth or ninth cartilages—something we did not realize at first (Fig. 8). The xiphoid is then detached from the sternum, the ventral mediastinum entered, and the loose tissue pushed off the posterior surface of the sternum. No attempt is made to separate the substernal ligament from the sternum as its division, when the ventral mediastinum is entered, is sufficient. A trasverse wedge osteotomy is then done across the third sternal segment through the anterior table only, leaving the posterior table intact, and the sternum is elevated to a normal position by producing an incomplete fracture along this line. Two pairs of holes are drilled in the lower end of the sternum and two stainless steel wires threaded through these holes across the back of the sternum (Fig. 9). The ends of the wires are brought through the skin and muscle on each side of the incision and the wound closed. The elevated position of the sternum is maintained by traction on the wires whose ends are then fastened into an external appliance placed transversely across the chest.

Some of the technical details of the operation need further elucidation. A longitudinal midline incision is made from the level of the second sternal segment to a point about 4 cm. above the umbilicus. The skin and subcutaneous tissues are dissected up and

retracted laterally. The pectoralis major muscles are separated from their sternal attachments and likewise retracted. The rectus abdominis muscles are split longitudinally through sheath and muscle to expose the costal arch (Fig. 8). Because the costal arch is narrow and the sides drawn towards the midline by the deformity an adequate exposure can be obtained without undue retraction. The cartilages are resected subperichondrially and this

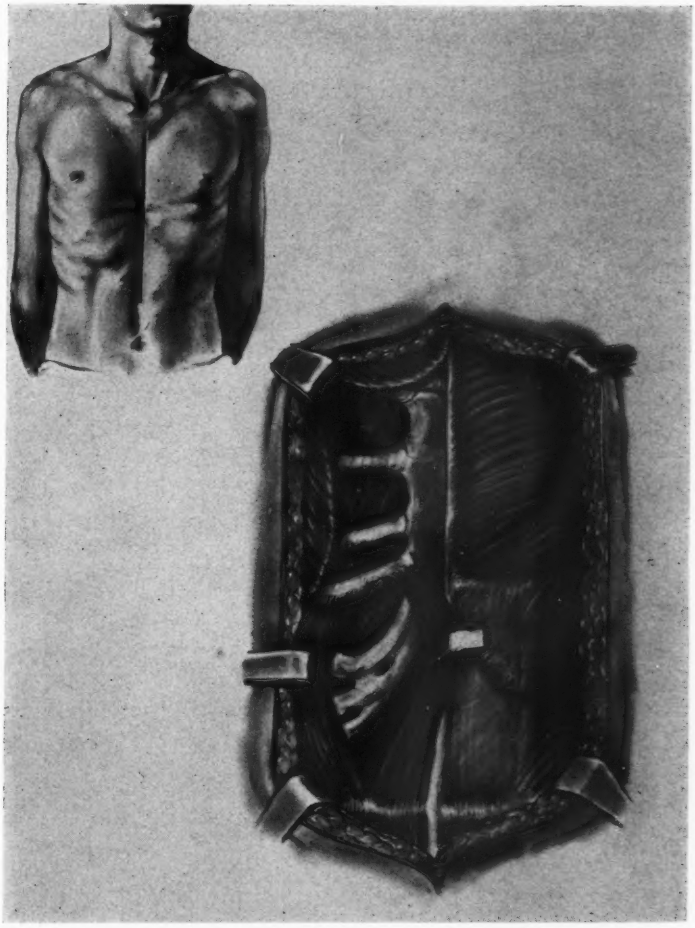


Fig. 8.—Radical operation. Exposure for resection of cartilages. In the right half the pectoralis major has been separated from the sternum and retracted exposing the individual costal cartilages below the second. The rectus abdominis has been split and retracted to expose the costal arch, the narrow arch making this exposure possible. Incision shown in insert.

is a slow and tedious procedure which must be done with great care to avoid tearing the pleura. The perichondrium is left so that the cartilages will regenerate. The wedge osteotomy is done with a small hand skull saw and a chisel. Stainless steel wires, 22 gauge, are used instead of silver because they are stronger. In a large boy or an adult one or both wires should be double.

The external appliance (Fig. 10) was evolved from Brown's ladder and has proved more satisfactory. It is made of duralumin and curved so that the central, fenestrated portion is higher than the ends, thus permitting overcorrection of the sternum. The small

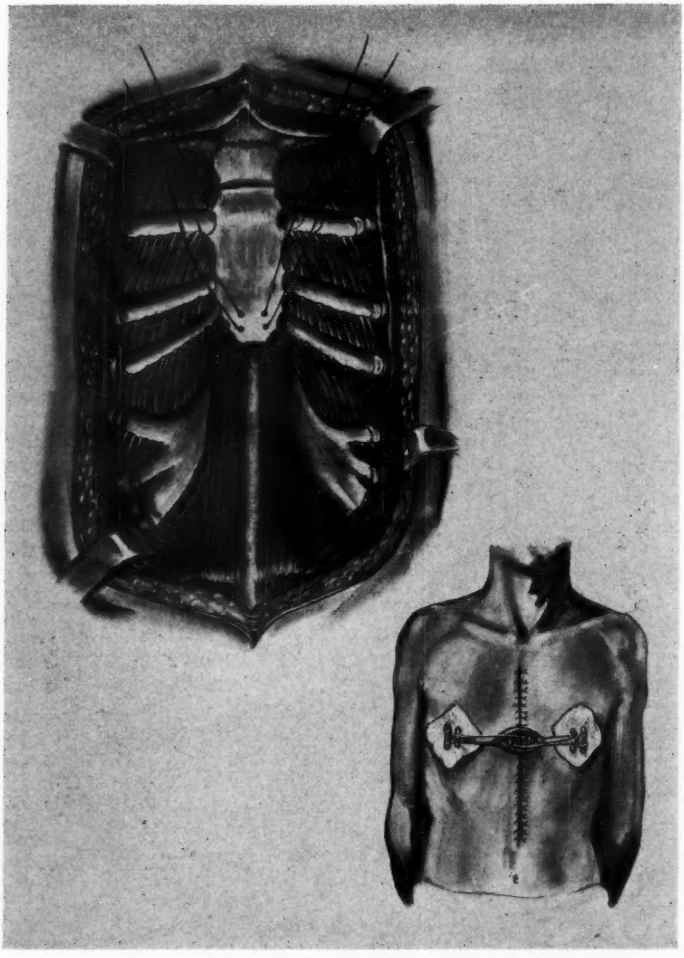


Fig. 9.—Radical operation. The cartilages have been resected, the xiphoid detached and allowed to retract, the wedge osteotomy completed through the outer table across the third sternal segment, and the wires threaded through the drill holes. Insert shows wires brought out through skin on each side of the incision which has been closed, the sternum elevated by the wires and the wires twisted into the ladder.

transverse bars at the ends are used as cleats on which to wind the wires. This permits loosening or tightening of the traction, should either be necessary, and avoids the weakening of the wires which occurs when they are twisted together. The ends of the ladder in contact with the chest wall should be well padded (Fig. 11).

The ladder is left on for two weeks. By this time the chest wall has stiffened sufficiently so that paradoxical breathing will not take place except during forced respiration. If the patient has a cough or is a screaming child it will be safer to leave the ladder on a few days longer.

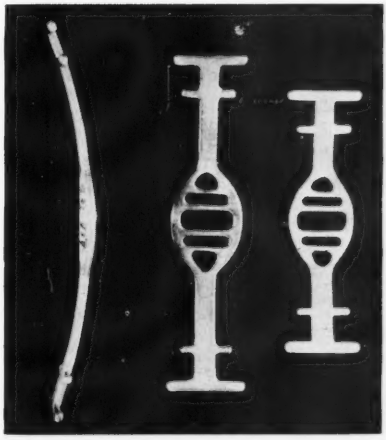


Fig. 10.—Three sizes of ladder. The largest is shown on its side to demonstrate the curve.

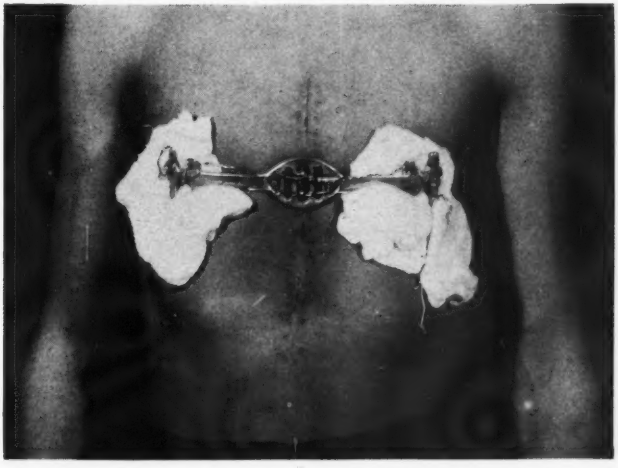


Fig. 11.—Photograph of a patient after operation with ladder in place.

This operation will suffice in most cases. When the only deformity is the prominence of the lower margin of the transverse groove, this can better be corrected by resecting the prominent cartilages or ribs and allowing the chest wall to sink to the level of the groove, rather than by trying to elevate the depression. If there is also some pull on the xiphoid, this bone should be

detached as in the operation for infants (Fig. 12). Operations of this sort are done for cosmetic reasons and, as the deformity varies with the individual, should be planned to fit the case.

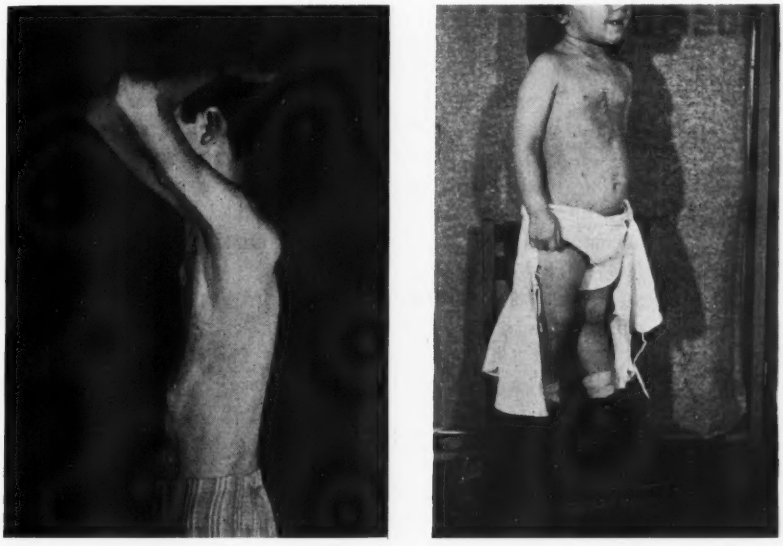
After operation the patient is given oxygen by means of tent, mask, or catheter. Pneumothorax is a common complication, often unrecognized, and whether or not it is present, the more quiet respiration which oxygen permits is grateful to the patient. Although there should be no great loss of blood, the operation is apt to be long and a blood transfusion during the operation is a good precaution. After operation it is advisable to have a portable roentgenogram taken. Any pneumothorax which it may disclose is corrected at once by aspiration. The position, both in bed and when allowed up, should be one which will correct the exaggerated dorsal curve that is characteristic of the deformity.

Fig. 12.—Individualized operation (Fig. 4, *A*). Prominences of lower part of groove resected through lateral incisions and xiphoid detached through central incision.

The optimum time for operation is the subject of many queries. In an earlier communication[3] we advocated the simple operation in children under 2 years of age but our late results have been disappointing. This is true even when the next pair of cartilages has been resected and the sternum bent up. Follow-up shows that, although the lower end of the sternum is not retracted during inspiration and any pressure on the thoracic organs has been relieved, the deformity still persists to a greater or less degree and has not diminished very much during three years of growth. As the parents bring the child for operation because of the deformity, they consider surgery a failure, even though the child is entirely healthy in other respects and is growing at a normal rate. In 2 patients operated upon at about the age of 1 year the results have been good but in 8 others, somewhat older, they have been equivocal so we prefer to reserve this operation for very young children in whom the deformity is severe and pressure symptoms present.

The radical operation performed on patients between the ages of 2½ and 4½ years has given the best results (Fig. 13, *B*). After 5 years of age, and sometimes earlier, permanent changes in the bony structures have developed which cannot be entirely corrected (Fig. 13, *A*). However, operation can be done at any age with the assurance that it will relieve pressure symptoms and probably bring about an 80 per cent correction of the deformity.

The complications characteristic of the operation are not many but are important. The first and most usual is pneumothorax. The perichondrium is so adherent that it is extremely difficult to separate it from the under side of the costal cartilages without tearing the pleura somewhere. The complication is not serious if recognized, even though it may be bilateral. If the opening is too small for the anesthetist to inflate the lung, the air can be aspirated after the wound is closed and there need be no sequelae.



A. *B.*

Fig. 13.—*A*, Postoperative result in patient with irreversible changes (Fig. 3, *A*). Sternum fairly well elevated in spite of breaking of wires on second postoperative day but narrow, flattened thorax unchanged. *B*, Postoperative result in child 2 years of age (Fig. 3, *B*). Sternum well elevated and deformity corrected because irreversible changes have not yet occurred.

Breaking of the wires in the early postoperative period is a distressing circumstance with serious possibilities. If it happens in the first few days after operation the resulting paradoxical respiration with the atelectasis and pneumonitis which usually follow may be dangerous in the extreme. If it happens later in the course it is not as serious. Replacement of the original silver wire with two of stainless steel has done much to eliminate this complication.

Infection has not been a troublesome problem. In the days before antibioties we had three instances of serous drainage which persisted for about one

week but we have yet to encounter a purulent infection. The reason for this may be that the wires act as setons and, of course, penicillin is now used prophylactically.

Edema of the glottis or subglottic region is a complication which must always be considered when endotracheal anesthesia is used in children. Because of the danger of accidental pneumothorax during operation this type of anesthesia must be employed, but in a long operation it certainly predisposes to postoperative tracheal obstruction and a tracheotomy set should always be available near the bedside after operation.

Results have been excellent with respect to the relief of pressure symptoms and in no instance have we had a failure in this category. In certain cases, however, cosmetic results leave something to be desired. This has been discussed with respect to the simple operation. In the older patients the irreversible changes which are prone to develop after the age of 5 years cannot be corrected by elevating the sternum. Flattening and narrowing of the chest due to the downward slant of the ribs will persist. The exaggeration of the normal dorsal vertebral curve can be rectified by corrective exercises if the patient will persist in them. The flare of the lower ribs at the costal arch will give the appearance of a funnel chest after the sternum has been elevated to its normal position and for this reason we have extended the operation to include the cartilages which make up the lower margin of the transverse groove. With this procedure the deformity in this group can be about 80 per cent corrected, depending on the amount of irreversible change, and the patients seem to be satisfied.

The best results have been obtained in the age group between 2½ and 4½ years. There are 5 of these in whom we have done the radical operation and the defect seems to be almost 100 per cent corrected. These cases are all fairly recent and the children have many years of growth ahead of them so no predictions as to the ultimate result should be made at this time.

There have been no deaths among the 31 operative cases.

SUMMARY

It can be said that congenital shortening of the central tendon of the diaphragm produces a variety of deformities in the thoracic cage, the most common and most serious of which is funnel chest. The incapacitating symptoms are due to pressure on the heart. Radical operation in which the costal cartilages are resected, the xiphoid detached from the sternum, and the sternum elevated will relieve the pressure symptoms and bring about a considerable correction of the deformity. The best results are obtained when the operation is done before the age of 5 years.

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DISCUSSION

DR. ALTON OCHSNER, New Orleans.—This presentation is certainly an interesting one, and Dr. Lester is to be congratulated on the number of cases he has had. Dr. DeBakey

and I made our report to this organization just ten years ago, and we agree with Dr. Lester's conclusions today that the radical procedure is the desirable one. Of the various methods used we preferred the one we used at that time (slides).

This shows a severe case in a girl. The mobilization of the sternum and costal cartilages is shown here, then the fixation with immobilization in a plaster shell. We have used the Parham-Martin band, because in our experience the wire is likely to cut through; one can use two bands—in this particular case we used one—the plaster shell is prepared beforehand and this is held up with rubber bands. This is the end result.

I would also like to emphasize the importance of long follow-up in these cases, because they do not do as well as we might hope. Recently we had a patient, a man 34 years of age—and his age is of importance—who had a typical chŏnē-chondrosternon of the worst type I had seen, and we hoped we might do the same procedure. However, when we got in we found there was so much deformity and so much fixation that mobilization and elevation would not be possible because this extended back so far. We did a procedure which Dr. DeBakey and I, in our presentation ten years ago, said should not be done because it was contrary to all surgical principles. This was first done by Lexer and reported by Hofmeister in 1927. It consisted of turning the sternum and costal cartilages inside out. This has been done several times, in several instances with bad results because of gas bacillus infection. Because of that we meticulously cleaned off all the muscle, leaving only bone and cartilage, and this view shows the result. It was possible to fix the costal cartilages to the side; as a matter of fact we had redundant cartilage. The result has been extremely satisfactory. In the older patient in whom there is marked fixation and marked change, particularly if the deformity extends quite far laterally, I would suggest that the Lexer procedure is a feasible one and will give a good result. But one must remove all the muscle to prevent possible anaerobic infection subsequently. The bone and cartilage will be maintained as a cartilage and bone graft, apparently without any difficulty.

DR. J. E. DAILEY, Houston.—Many techniques have been devised in correcting funnel chests, and I wish to introduce another method in which no casts or any appliances whatsoever are necessary (slides). This could be called, "a rib graft elevation of the sternum." These slides illustrate a 13-year-old girl with quite a marked depression, and the postoperative result. The lateral view shows the marked depression of the sternum. The patient also had electrocardiographic changes and marked cardiac embarrassment. The next slide is a postoperative roentgenogram showing quite a marked improvement in the depression.

The operative procedure in this case consisted in removing a segment of the ninth rib, leaving the periosteum on one surface, then all the cartilages were completely resected on both sides of the sternum leaving the pericondrium. The sternum was elevated. The segment of rib that was removed was then used as a bridge from the second rib on one side to the third rib stump on the other side and wired in place, and the sternum was allowed to rest upon that rib. The perichondrium was then tacked up around the edges of the sternum. The rib placed beneath the sternum, effectively held it in place and the postoperative use of a cast or some suspensory appliance was totally unnecessary.

It is suggested that this technique might be applicable in certain cases of severe crushing injury to the chest in which it might be of value to immobilze the sternum, and counteract paradoxical respiration.

DR. FORRESTER RAINE, Milwaukee.—Along with Dr. Ochsner's remarks about having to turn the sternum when there was such a terrific depression, I have found that by simply splitting the sternum lengthwise with a saw, it can be folded out, and the depression disappears quite well without having to turn it over and it really becomes fixed remarkably so that there is no instability two weeks later. I think that might be simpler than turning it over.

DR. A. L. BROWN, San Francisco.—I do not rise to defend one procedure over another. I think we have come beyond that point. However, I would like to mention our experience in 27 of these cases during the past fourteen years; 12 were the infant type

procedure, and by this we mean 2 years of age or under; when we speak of the adult type it is over that age. In the infant type if they are done when the development of the defect is still going on you get a result. If you do it after that you get no result.

So far as technique goes, we do not use any support at all. The whole trick, so far as I am concerned, is in freely developing motion of the sternum, overcorrecting the defect, and the sternum sits up by itself. Then if you wish you can put an extra suture in any one of the rib stumps that seems to be pretty close to the sternum; it will stay up whether you put that in or not. We have reached the point where we are trying to evaluate when one should do the operation. People come for two reasons; one is for the cosmetic result, and that is important; but the other is, for a person without symptoms with the defect or a child who is developing the defect, should you advise operation? The end results, from the cosmetic viewpoint, have been very good in children and fair in adults. I would say about 75 per cent in the adults. We have had no mortality in the 27 cases. But from the functional standpoint, where the patient presents himself with symptoms, the end results have been poor, uniformly poor, and that has led us to undertake cardiorespiratory studies on these patients before surgery and as soon as they are seen. In the early cases this is difficult but as they get along in age you can make good studies and, surprisingly, the adult has some cardiorespiratory signs before he is conscious of them (slides).

This is an outline of the studies we are now making. This child had lung on only one side. Postoperatively all get an immediate response in the breathing reserve, and the breathing capacity is immediately increased. This shows an adult of about 33 years of age, who started with a very fine vital capacity, very marked deformity. We do not consider that vital capacity means anything. The maximum breathing capacity before operation was 15, and 32 immediately after. However, they drop as months go on.

This slide shows the development of the pectus in a child; you see what is going on. There is neuromuscular imbalance which gradually causes permanent shortening in the antero-posterior diameter of the diaphragm.

At present we are trying to determine when operation should be advised and as it stands now, we think you cannot do it early enough.

DR. HENRY A. BRODKIN, Newark, N. J.—I am of the opinion that rickets plays no part in the formation of anterior deformities of the chest, commonly called funnel chest, pigeon breast, and Harrison's grooves, which I had the temerity to name congenital chondrosternal depression, congenital chondrosternal prominence, and congenital costochondral depressions, respectively. I believe these deformities result from the altered contractions of an abnormally developed diaphragm.

The importance of the diaphragm in respiration is realized when one reflects on the fact that a young animal will die of respiratory failure when both its phrenic nerves are severed. I believe further that it is chiefly the influence of the action of the diaphragm that changes the contour of the infantile round chest to the elliptical "adult" contour at the end of the first year.

After observing the synchronous retractions in the anterior chest wall during inspiration with the contraction of the diaphragm in two infants, one with a congenital chondrosternal depression (funnel chest) and the other with a congenital chondrosternal prominence (pigeon chest), a phrenic nerve of each was injected with 1 per cent Novocain. The retraction in each deformity ceased on the side injected. This was strong evidence to me that the deformity was produced by the contractions of an abnormal diaphragm.

After reviewing the embryology of the diaphragm and studying the diaphragms of various animals, I came to the conclusion that a normal diaphragm has a definite anatomic structure with a definite structural ratio between its circumferential radial musculature and its trefoil membranous portion. It consists of four fused segments, an anterior, two lateral, and a posterior, each separated by a fibrous raphe, derived respectively from the anterior septum transversum, the two lateral pleuroperitoneal membranes, and the dorsal mesentery. Contraction of a normal diaphragm exerts its traction on the membranous portion. If the membranous portion extends to the sternum or if the normal structural ratio is not present,

undue traction on the anterior chest wall results and a deformity is produced. This theory is described by me in the March, 1949 issue of Pediatrics.

The only diaphragm associated with a congenital chondrosternal depression was seen by me in a 4-week-old suckling puppy. Its anterior segment (derived from the septum transversum) appeared practically absent and its membranous portion instead of being trefoil consisted of two leaves which were fused anteriorly and attached to the xiphoid-gladiolar junction.

I found the anatomy of the diaphragm quite different in a 14-month-old infant with a congenital chondrosternal prominence (pigeon chest). The membranous portion was in the shape of an inverted letter "V." The anterior portion contained few thin muscle fibers compared to the strong muscle fibers of the lateral portions. The contraction of such a diaphragm apparently produces this type of deformed chest, namely, a round full "infantile" upper half which forms the prominence and a comparatively retracted lower half of its anterior wall.

As a result of these observations and studies, I feel that congenital deformities of the anterior chest wall result from the contractions of a congenital abnormally developed diaphragm.

In patients with congenital chondrosternal depressions, I employ an inverted "Y" incision. For the correction and maintenance of the sternum I suture a free cartilage graft, taken from the costal margins, under the end of the elevated sternum to the ends of the fifth cartilage.

DR. PAUL HOLINGER, Chicago.—The problem of funnel chest is of interest to the laryngologist as well as the thoracic surgeon. Any chronic laryngeal obstruction will result in temporary and possibly permanent funnel chest deformity. This is seen in infants and children with laryngeal papillomatosis or with so-called "congenital laryngeal stridor." In the latter condition, the larynx is soft, flaccid, and slightly edematous and on each inspiration the arytenoids, aryepiglottic folds, and curled epiglottis are sucked into the glottic lumen to cause obstruction. This is often severe enough to result in extreme sternal retraction with the epigastrium drawn back to the spinal column on inspiration. It is certainly conceivable that the shortening of the ligament of the diaphragm, which is considered an etiologic factor of funnel chest, is the result rather than the cause of the retraction of the sternum. The retraction in congenital stridor is usually present at birth and increases in severity with an alarming increase in the loud stridorous sound on inspiration until the infant reaches 10 to 12 months of age. Thereafter the noisy breathing gradually decreases and at 2 or 3 years of age breathing is entirely normal; the larynx has assumed its normal rigidity and stays patent on inspiration. But, in the severe cases, the infant has developed a chest deformity with flaring of the ribs and, to a greater or lesser degree a funnel chest.

The extreme deformities presented by Dr. Lester certainly required operative repair. But indications for surgery in some of the operated infants shown by discussants might be questioned, especially when expiration films of the chest showed a normal anteroposterior diameter of these chests. In such cases, the deformity could hardly be considered as due to a shortened diaphragmatic ligament, since then the deformity would be evident on expiration as well as on inspiration, although possibly not to the same degree. I think, therefore, that before operating any infant for this chest deformity, a careful study of the larynx should be made by direct laryngoscopy; and that the likelihood of a spontaneous disappearance of the deformity as the infant reaches 2½ to 3 years of age is great. The indication for surgical intervention might better be the degree of displacement of mediastinal structures rather than the degree of substernal retraction on inspiration.

DR. JEROME HEAD, Chicago.—We have recently had a case of this type which we handled in a different manner. It seemed to us the deformity could be corrected best by applying force in the opposite direction from the force which had been applied to create the deformity, and doing this without resection of cartilage or transection of the sternum.

Transecting the sternum and removing the cartilage tend to elevate the whole deformity rather than correct it, and correct the deformity of the ribs which had been occasioned by depression of the sternum. Therefore we made an incision and removed the xiphoid cartilage and simply put a hook under the lower end of the sternum, out through the skin, and applied traction to it. To hold the hook in place we put a stainless steel wire beneath the sternum and fastened that around the hook to hold it. After ten days we removed the hook from beneath the end of the sternum, and since then have applied traction early by rubber bands attached to the wire which runs beneath the sternum (slides). We did not use the bridge across the chest as we did not want to apply counter-pressure to the ribs, and felt if we were pulling the sternum out we would also be pressing the ribs back. In this case the heart had escaped to the right, which is rather unusual. There is a residual deformity on the left, and we plan to put wire there and pull this out in the same manner. The principle is the same as dentists use in correcting malalignment in teeth.

DR. LESTER.—I appreciate the discussion which has been evoked. Dr. Ochsner's plaster shell for correction I think is admirable, and one can certainly get good correction by taking the sternum out and turning it over. I should say it would take some time to heal, during which it keeps the patient in bed in a plaster shell; and the same thing applies to Dr. Head's appliance. The results are good, there is no question, but the children with the external appliance which Dr. Brown has used and which he has given up, are allowed up and out of bed about the third day, and are running around the wards without any disability.

This is Dr. Brown's baby, really. It is his operation, and I am interested in his remarks on giving up the use of the ladder. We find that when the wires have broken we get a great deal of paradoxical motion. In the 19-year-old boy I showed this was extreme and had us much worried for two weeks. Every time he breathed the sternum flopped back and forth like a flag in the wind. In the obstruction situation that Dr. Holinger mentioned, that is in line with the observation made by Dr. Emmett Holt, Jr., Professor of Pediatrics at New York University. He has been interested in these cases and he suggested some sort of laryngeal obstruction as a possible cause of the trouble, and he delights in calling me up to see children that have laryngeal obstruction with retraction of the sternum during forced inspiration. Of course, you get that in any type of laryngeal obstruction. That is one of the cardinal signs of laryngeal obstruction which may call for tracheotomy. I think, however, that you cannot correct a true funnel chest by correcting that obstruction, and many do not have an obstruction at all. However, when a child has large tonsils or other evidence of obstruction to his upper respiratory tract, we always correct that before we try to correct the chest.

AN EXPERIMENTAL STUDY OF THE BLOOD SUPPLY OF THE ESOPHAGUS AND ITS RELATION TO ESOPHAGEAL RESECTION AND ANASTOMOSES

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INTRODUCTION

THIS series of experiments was ventured upon to ascertain whether or not the blood supply of the esophagus of the dog is adequate to tolerate a resection with end-to-end anastomosis.

METHODS OF SURGERY

Thirty-two dogs, whose average weight was 15 pounds, were used in these experiments. A preoperative dose of morphine sulfate, 0.09 Gm., and atropine sulfate, 0.004 Gm., was given one hour before surgery. Positive pressure endotracheal ether and air anesthesia was used. The left pleural cavity was entered through the bed of the sixth rib, which had been resected.

In these experiments, varying lengths of the esophagus were resected and it was denied of varying amounts of blood supply. In all experiments the resected ends of esophagus were reunited by single interrupted horizontal mattress sutures of 00000 silk in two layers. The esophagus was then replaced in its mediastinal bed, except in two dogs of the first experiment. These had the esophagus transplanted anterior to the aortic arch.

The mediastinal pleura was not closed. The lungs were re-expanded, 100,000 units of penicillin were left in the pleural cavity, and the thoracic wall was closed in layers with interrupted sutures of cotton.

Immediately postoperatively, the animals were given 100,000 units of penicillin intramuscularly. No more penicillin was administered.

Food was denied the animals for the first twenty-four postoperative hours. During the next four days a diluted mixture of the ordinary dog food was given. Following this, the animals were given a regular diet of commercial dog meal, mixed with water.

METHODS OF ARTERIOGRAPHY

For all arteriograms, the thoracotomy wound was reopened, and the pleural cavity entered, using the aforementioned surgical technique. The lung was packed away to visualize the esophagus. A right rectus abdominal incision was made and the diaphragm divided. Through this thoracoabdominal incision, ample delivery and mobilization of the stomach was achieved. It was essential that the animal remain alive, for in these experiments, the propulsion of the opaque media was accomplished by the animal's arterial pressure.

The media used in the first arteriogram was a mixture of 20 per cent bismuth oxychloride in 1 per cent starch solution. The bismuth was easily seen through the arterial walls. In all other experiments a mixture of 18 per cent bismuth

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oxychloride in 35 per cent Diodrast was used. This media was easier to work with as it flowed more easily through a 25 gauge hypodermic needle. The amounts of media injected varied from 8 to 30 c.c.

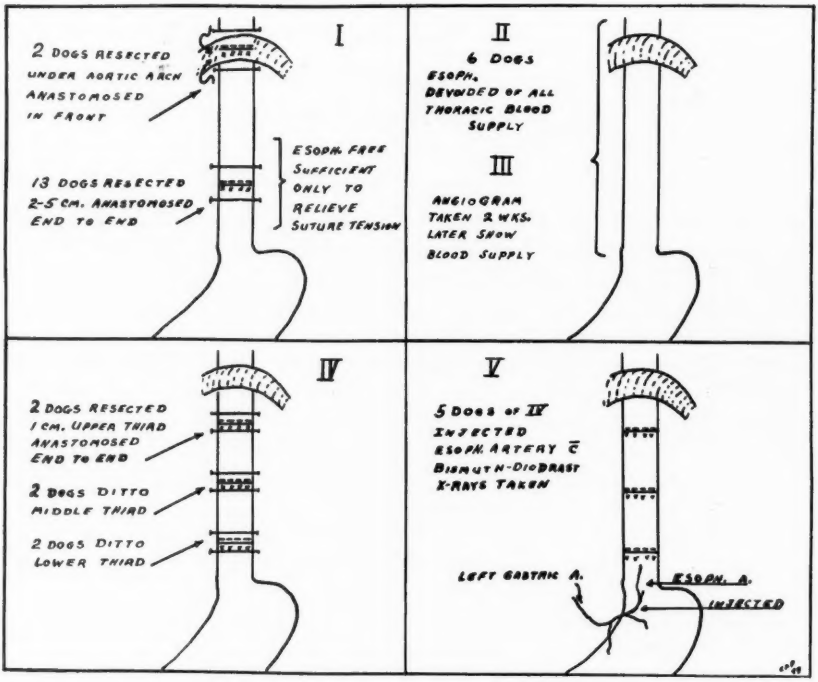

I
2 DOGS RESECTED UNDER AORTIC ARCH ANASTOMOSED IN FRONT
13 DOGS RESECTED 2-5 CM. ANASTOMOSED END TO END
ESOPH. FREE SUFFICIENT ONLY TO RELIEVE SUTURE TENSION
II
6 DOGS ESOPH. DEVOIDED OF ALL THORACIC BLOOD SUPPLY
III
ANGIOGRAM TAKEN 2 WKS. LATER SHOW BLOOD SUPPLY
IV
2 DOGS RESECTED 1 CM. UPPER THIRD ANASTOMOSED END TO END
2 DOGS DITTO MIDDLE THIRD
2 DOGS DITTO LOWER THIRD
V
5 DOGS OF IV INJECTED ESOPH. ARTERY C BISMUTH-DIODRAST X-RAYS TAKEN
LEFT GASTRIC A.
ESOPH. A.
INJECTED

Fig. 1.—Diagrammatic sketch. *I* refers to Experiment I; *II* and *III* refer to Experiments II and II, A; *IV* refers to Experiment III, and *V* refers to Experiment III, A.

When the left gastric artery was injected, all vessels to the right were ligated and the right half of the stomach was clamped to prevent unnecessary filling in this direction. When the right gastric or right gastroepiploic arteries were injected, the duodenum was clamped and the vessels to the omentum were ligated. After introduction of the needle into the artery, a ligature around the artery held the ensheathed needle in place. The injection was made slowly in order to allow the blood to carry the media and to avoid vessel rupture.

After all arteriograms, the stomach and esophagus were removed as a specimen. X-ray films were then made. The dog was sacrificed and if previously operated, an autopsy performed.

EXPERIMENTS

I. To Determine the Feasibility of an End-to-end Anastomosis of the Thoracic Esophagus (Fifteen Dogs Used)

Varying lengths in the esophagus were freed from their blood supply in that area which reached from the diaphragm to the arch of the aorta (Fig. 1).

In these freed areas, portions of esophagus ranging in lengths from 3 to 5 cm. (that is, approximately one-seventh to one-fourth of the entire thoracic length), were resected. The esophagi of two of the fifteen dogs were resected at the level of the aortic arch. The esophagus was transplanted from behind the arch and the anastomosis was made anteriorly.

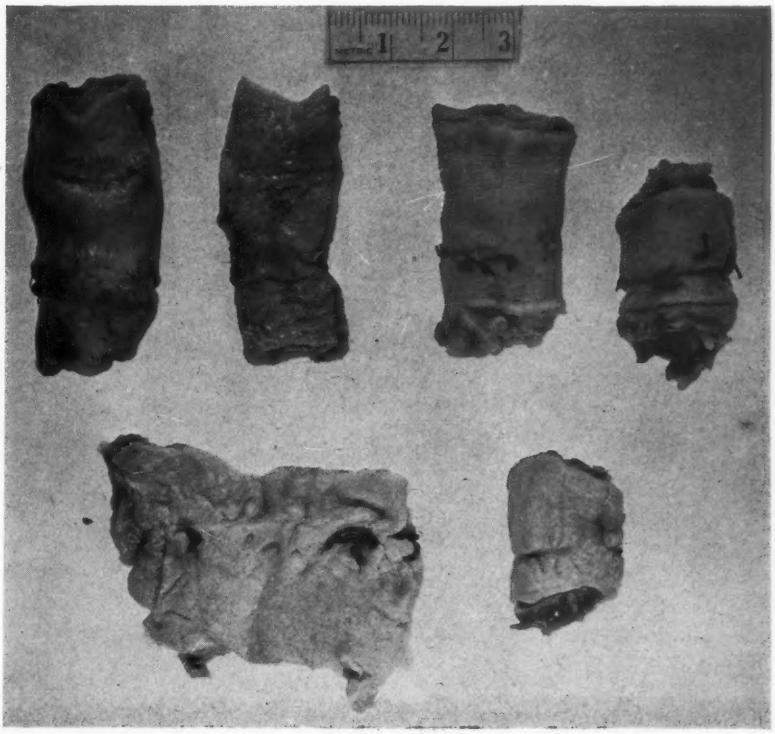


Fig. 2.—Autopsy specimen of esophagi more than two months after resection and anastomosis. First two, upper left, show muscularis surfaces. Others show mucosal surface after specimen is turned inside out. (Experiment I.)

Results.—The animals recovered. Seven dogs were noticed to retch during the second week whenever solid food was eaten too rapidly. Esophagoscopy was done, and revealed no visible stricture. Fourteen dogs survived the operation for longer than two months and were then sacrificed. One dog died on the twenty-second postoperative day. An autopsy on this animal revealed patchy consolidation of the left lung due to bronchopneumonia. The esophagus had a well-healed suture line around which there was no evidence of infection. In the fourteen dogs sacrificed, the anastomosis in each instance was perfectly healed and there was no evidence of stricture (Fig. 2).

II. To Determine the Viability of the Esophagus Devoid of Its Entire Thoracic Blood Supply (Six Dogs Used)

In this experiment, the entire length of the esophagus was freed and all its thoracic blood supply was severed (that is, those vessels from the bronchial and intercostal arteries, as well as those from the thoracic aorta and aortic arch).

Results.—All six dogs survived the operation, and five lived and ate well for a period longer than fourteen days, after which they were used for arteriogram studies. The sixth animal died on the fourth postoperative day and an autopsy revealed a dilated right heart. The esophagus was viable. At autopsy, done subsequent to the following experiment, the esophagi of the remaining five animals appeared normal.

Fig. 3.—Experiment II,A. Arteriogram showing injection media carried to upper one-fourth of esophagus, after being injected into the right gastric artery.

A. To Determine by Arteriogram How Much of This Esophagus Is Supplied by Branches From the Left Gastric Artery (Same Dogs Used as Were Used in Previous Experiment).—Using the aforementioned arteriography technique, the left gastric artery was injected with approximately 10 c.c. of the prepared media.

Results.—The injection media was carried from the gastric arteries into the esophagus and passed upward to approximately its upper one-fourth (Fig. 3).

III. To Determine the Adequacy of the Blood Supply From the Left Gastric Artery in Healing an Anastomosis Done After Resection at Different Levels in the Esophagus Devoid of All Thoracic Blood Supply (Six Dogs Used)

In all animals in this experiment, the esophagus was deprived of its thoracic blood supply. In each pair of dogs 1 cm. of the lower, the middle, and the upper third of the esophagus was resected. The anastomosis was made as before.

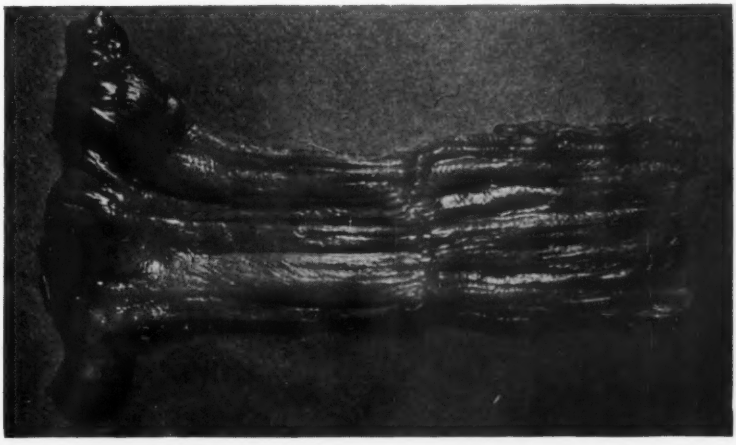


Fig. 4.—Experiment III. Anastomotic line on mucosal surface three weeks postoperative.

Fig. 5.—Experiment III,A. Arteriogram of esophagi, three weeks after resection and anastomosis. Injection media seen carried to level of anastomosis and beyond.

Results.—All six dogs survived the operation. Five lived for three weeks, at which time they were reoperated upon for the next experiment. The sixth is still alive after eight weeks. Subsequent to the following experiment, autopsy of the five dogs revealed good healing of the esophagus and no evidence of stricture (Fig. 4).

A. Arteriogram Study of the Esophagus Three Weeks After It Has Been Resected at Different Levels and Anastomosed When Devoid of All Thoracic Blood Supply (Same Five Dogs Used as Were Used in Previous Experiment).—In this experiment, the left gastric artery was injected with 8 to 16 c.c. of the prepared media, using the previously described technique.

Results.—Arteriograms revealed clearly the adequacy of the blood supply of these esophagi as shown by the fact that the injection media was carried to the line of anastomosis or beyond (Fig. 5).

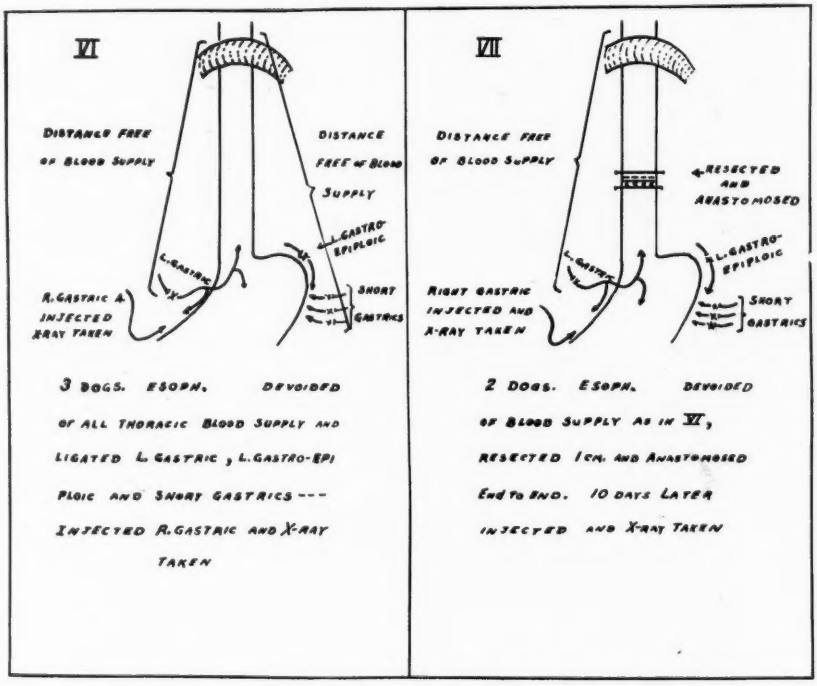

VI
DISTANCE FREE OF BLOOD SUPPLY
DISTANCE FREE OF BLOOD SUPPLY
L. GASTRIC
L. GASTRO-EPIPLOIC
R. GASTRIC A. INJECTED X-RAY TAKEN
SHORT GASTRICS
3 DOGS. ESOPH. DEVOIDED OF ALL THORACIC BLOOD SUPPLY AND LIGATED L. GASTRIC, L. GASTRO-EPIPLOIC AND SHORT GASTRICS --- INJECTED R. GASTRIC AND X-RAY TAKEN
VII
DISTANCE FREE OF BLOOD SUPPLY
RESECTED AND ANASTOMOSED
L. GASTRIC
L. GASTRO-EPIPLOIC
RIGHT GASTRIC INJECTED AND X-RAY TAKEN
SHORT GASTRICS
2 DOGS. ESOPH. DEVOIDED OF BLOOD SUPPLY AS IN VI, RESECTED 1 CM. AND ANASTOMOSED END TO END. 10 DAYS LATER INJECTED AND X-RAY TAKEN

Fig. 6.—Diagrammatic sketch. *VI* refers to Experiment IV and *VII* refers to Experiments V and V, A.

IV. Arteriogram Study of the Esophagus After It Is Devoid of All Thoracic Blood Supply and the Left Gastric, Left Gastroepiploic, and Short Gastric Arteries Are Divided (Three Dogs Used)

This experiment was done to determine whether or not the blood from the right gastric artery could reach the esophagus by anastomotic channels. The

thoracic esophagus was freed as before. The diaphragm was opened and the stomach delivered into the thoracic cavity. The left gastric, left gastroepiploic, and short gastric arteries were ligated and severed. Immediately following this, the right gastroepiploic artery was injected with 20 to 30 c.c. of the prepared bismuth and Diodrast mixture. The esophagus and stomach were removed and an x-ray film made.

Results.—The x-ray films revealed that the injection media has been carried into the cervical esophagus (Figs. 6 and 7).

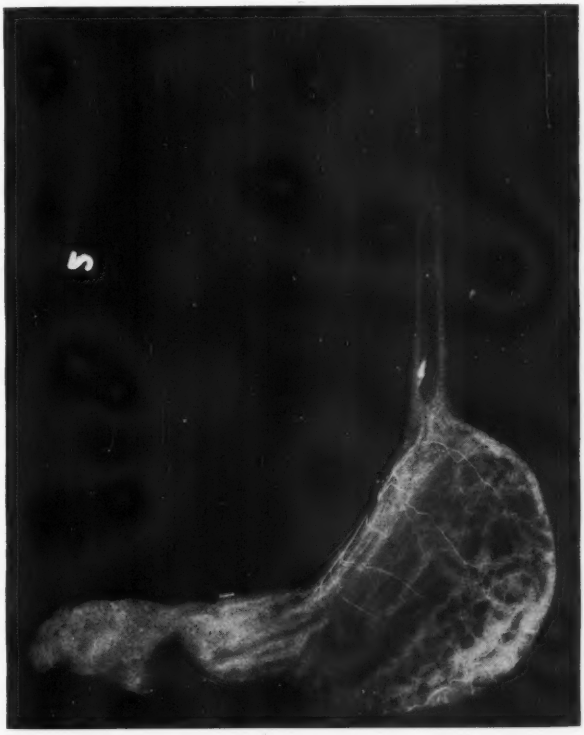
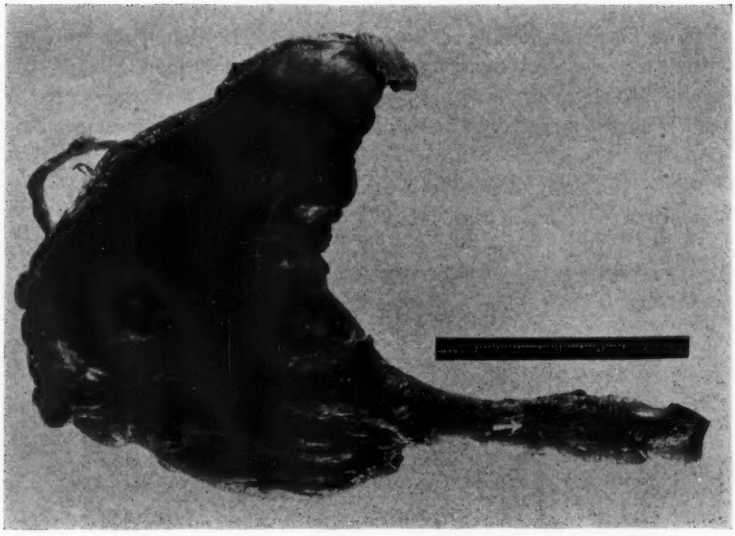


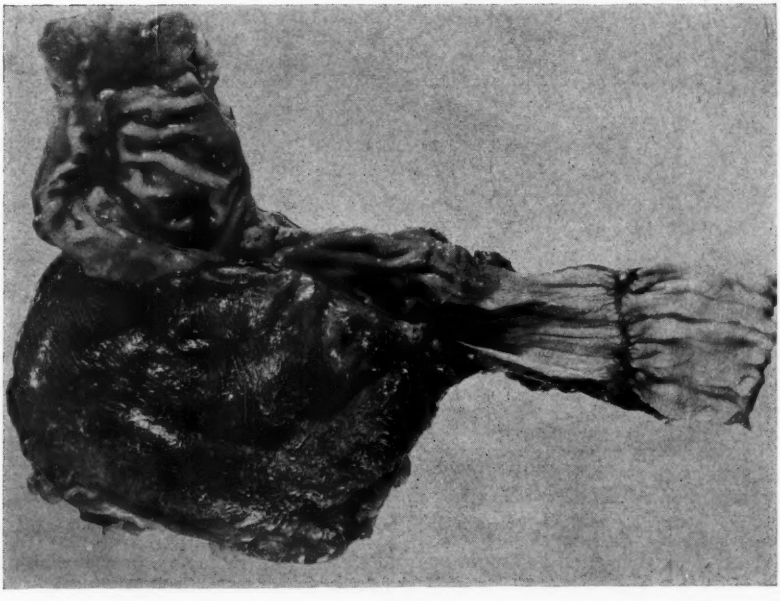
Fig. 7.—Experiment IV. Injection media seen carried into cervical esophagus from the right gastroepiploic artery.

V. A Study of Healing of an Esophagus Resected and Anastomosed After It Is Devoid of All Thoracic Blood Supply and the Left Gastric, Left Gastroepiploic, and Short Gastrics Are Divided (Two Dogs Used)

In this experiment, the esophagus was freed of all its blood supply as before, in addition to which the left gastric, left gastroepiploic, and short gastric arteries were ligated and severed. The esophagus was then resected of 1 cm. in the middle third and anastomosed end-to-end.

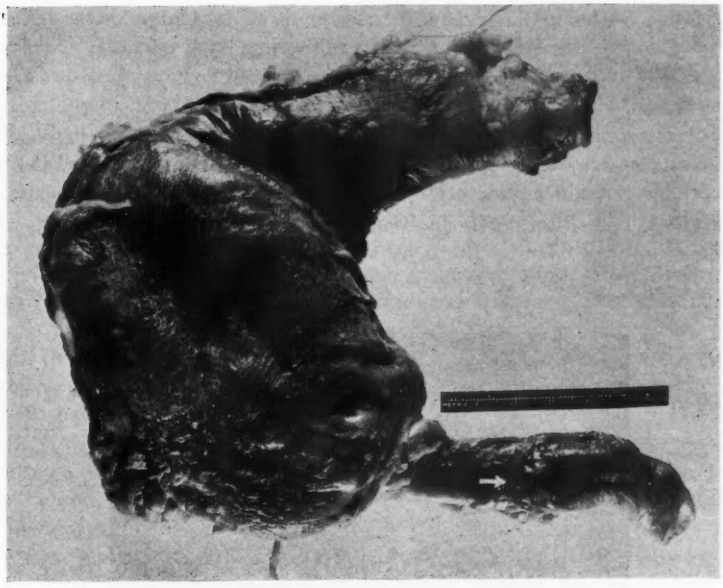


A.

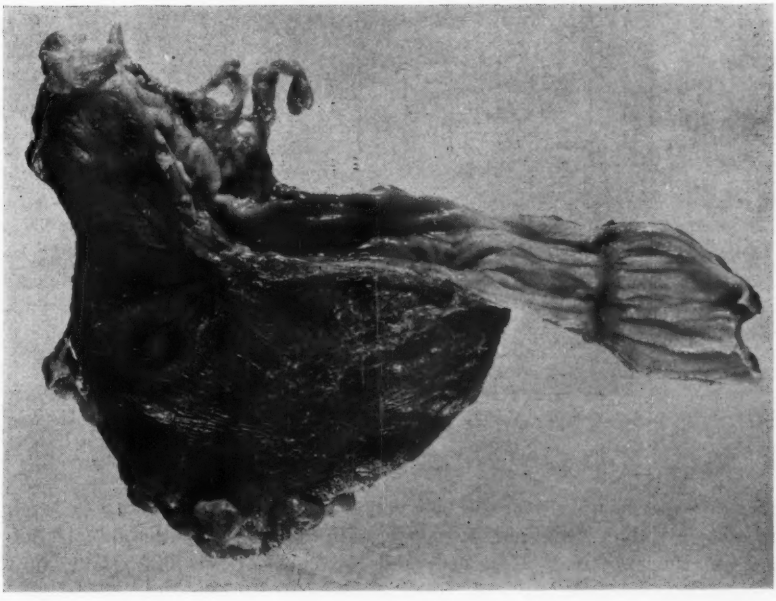


B.

Fig. 8.—Experiment V. *A*, Arrow points to anastomotic line on muscularis surface ten days postoperative. *B*, Anastomosis line on mucosal surface ten days postoperative. (Note ascaris lumbricoides at prepyloric region.)



A.



B.

Fig. 9.—Experiment V. *A*, Second specimen. Arrow points to anastomotic line on muscularis surface, ten days postoperative. *B*, Second specimen. Anastomotic line on mucosal surface, ten days postoperative.

Results.—Both dogs survived until sacrificed ten days later for the following experiment. Autopsy subsequent to the following experiment revealed good healing of the suture line and no evidence of stricture (Figs. 8, *A* and *B*, and 9, *A* and *B*).

A. Arteriogram Study of This (V.) Experiment (Same Two Dogs Used as in Previous Experiment).—The previous two dogs were reoperated and the right gastroepiploic or right gastric artery was injected with the prepared media.

Results.—The injection in one dog was poor, due to technical difficulties. The other, however, showed the injection media had reached the line of anastomosis (Fig. 10).

Fig. 10.—Experiment V,A. Arteriogram showing injection media carried to suture line.

DISCUSSION

These experiments reveal the fact that apparently the blood supply is much more adequate than had been previously supposed, both by the actual clinical healing in the experimental animal, and by the arteriographic studies of the esophageal blood supply.

It will be noted that in each instance where a portion of the esophagus was resected and then an anastomosis was made, healing occurred readily and well.

Interestingly enough, in this entire series of experiments no animal suffered immediate postoperative death. Two dogs died postoperatively, one on the fourth day from apparent right heart failure, and the second on the twenty-second postoperative day from a bronchopneumonia. In each instance, the esophagus was intact and no mediastinitis was present.

In these animals it has been well demonstrated that not only can the entire thoracic esophagus be deprived of its blood supply and survive well, but at the same time portions can be resected and the esophagus reunited by end-to-end anastomosis with perfect healing. This would tend to prove that the arterial supply from the gastric arteries is sufficient to nourish the entire esophagus.

Arteriograms made on animals whose entire thoracic and upper gastric blood supply had been ligated revealed the fact that the right gastric artery can, through its anastomotic connections, supply the esophagus as high as its cervical segment.

Criticism may be directed against these experiments in that no long-term animals (the longest is two months) have been reported. The fear may be raised that after a period of months, stricture may occur at the point of anastomosis. It will be noted from a perusal of Figs. 2, 4, and 7, that no apparent narrowing of the esophagus is evident. Experiments are in progress to clarify this point.

Antibiotics were used sparingly in these studies. This was done to test more drastically the adequacy of the blood supply.

CONCLUSIONS

1. Local resection of the esophagus with end-to-end anastomosis has been successful.

2. The entire esophagus can be freed of its thoracic blood supply and still remain viable.

3. When the entire esophagus is freed of its thoracic blood supply and is resected and anastomosis made, it heals well.

4. It has been demonstrated by arteriograms that the esophageal blood supply which is derived from the stomach, even though all the arteries except the right gastric are severed, is sufficient to keep the esophagus viable and heal an anastomosis.

(See discussion on page 537.)

THE TREATMENT OF SHORT ESOPHAGEAL STRICTURES BY RESECTION AND END-TO-END ANASTOMOSIS

W. M. Tuttle, M.D., and J. C. Day, M.D.
Detroit, Mich.

IT HAS long been believed that resection of portions of the esophagus and a re-establishment of the lumen by an end-to-end anastomosis was impossible. The lack of a supposedly adequate blood supply and the absence of a serosal coat reportedly would cause the anastomotic line to break down. It was for this reason that Adams and Phemister[1] and later Sweet[3] and Garlock[2] brought the stomach into the thoracic cavity and joined it to the esophagus above the resected tumor. The use of esophagogastrostomy to re-establish the continuity of alimentary tract following esophagectomy has proved a most useful and adequate procedure.

Often times in the course of resecting a long length of esophagus to overcome a very short area of stricture, we have been impressed by the magnitude of the surgical procedure used to correct the small but important defect. The thought arose, would not a direct attack with subsequent end-to-end closure be feasible, especially in view of the now prevalent view that healing in the esophagus takes place by proper approximation of the mucosal layer. Good union and healing without stricture is seen frequently when large diverticula of the esophagus are removed in a one-stage operation. If healing occurs in such defects, which are often large, why should it not occur in end-to-end procedures?

We were encouraged in this thought by the previously mentioned observations, by the adequate healing seen in the operative procedure of cardioplasty for achalasia, where often large areas of an exceedingly poor esophageal wall are joined to the stomach with gratifying results, and by the results of experiments carried out in our own laboratory.

At the onset we were not bold enough to resect completely the entire annular stricture and then directly reunite the superior and inferior aspects of normal esophagus. In patients previously operated upon who are not included in this group, the stricture was cut through longitudinally and the closure was made in two layers in a horizontal direction. These wounds healed well and function was restored. Such results encouraged us to proceed with the two types of operative procedures to be reported here.

MATERIAL

This report is based on the results experienced in five patients with esophageal stricture who ranged in age from 1 to 70 years. The areas of stricture varied in length from 1 to 2½ cm. The causative agent in none of the patients was clear, but in the two children it was obviously congenital, for symptoms of dysphagia had been present since birth.

From the Department of Surgery, Wayne University College of Medicine.
Read at the Twenty-ninth Annual Meeting of The American Association for Thoracic Surgery, New Orleans, La., March 29-31, 1949.

OPERATIVE PROCEDURE

The first type of procedure was used in three patients. The chest was entered through the bed of the eighth rib, the esophagus was freed from its bed, and the area of stricture was identified. The normal esophagus above and below the narrowed area was held upward on rubber drain slings. A triangular wedge of esophagus was then removed in such a manner as to preserve a small strand of esophageal tissue posteriorly to act as an anchor. The cut ends were then joined by interrupted sutures of fine silk, one layer being placed in the mucous membrane and a second layer in the muscularis and adventitia. The esophagus was then replaced in the mediastinum. The mediastinal pleura was lightly closed.

The second approach to this problem was used in two patients. In these patients the mediastinum was approached as in the first group. The esophagus was raised from the mediastinum and after the area of stricture had been identified it was completely resected. The lumen was re-established by an end-to-end anastomosis using fine interrupted silk sutures in two layers as in the first group with the exception that the resection was complete.

RESULTS

The long-term results from a standpoint of patient survival were not good. Three of the five patients are now dead. However, in none of the three who died at intervals of from a week to three months following surgery was there any evidence that the anastomotic line had broken down.

CASE REPORTS

CASE 1.—J. H., a Negro boy, 7 years of age, was delivered normally in 1941. It was noticed when the boy began to take semisolid food at the age of 9 to 10 months that some trouble was experienced in swallowing such a diet. This difficulty progressed and at the age of 2 years a gastrostomy was done. From that time until 1946, the esophagus was dilated both through the gastrostomy and through the upper esophagus. During 1945 and 1946, it appeared that he was able to eat with moderate ease, and the gastrostomy was allowed to close.

He apparently ate well but continued to show evidence of a persistent anemia. Numerous and careful studies of the blood failed to reveal the exact nature of his anemia. In March, 1948, he was again admitted to The Children's Hospital of Michigan. At this time there was evidence of a severe secondary anemia and dysphagia. X-ray studies revealed a definite stricture of the esophagus in its lower one-third. Esophagoscopy was done and there was a weblike stricture seen across the lower one-third of the esophagus. A filling defect was seen in the stomach. There was occult blood in the stool.

It was decided to explore the esophagus and stomach transthoracically. The patient's blood was brought to normal and on April 12, 1948, the operation was performed.

The chest was opened and the esophagus raised from its bed. The area of stricture was palpated and appeared approximately 2 cm. in length. It was decided to resect it locally and not to enter the stomach as it was felt that the filling defect in the stomach was due to the deformity caused by the previous gastrostomy.

Therefore, a wedge which included the stricture except for its extreme posterior portion was removed from each side. This left a narrow, 2 mm. band posteriorly, as an anchor. The esophagus was reunited with two layers of fine silk.

The postoperative course was uneventful and the patient was taking a full diet on the eighth postoperative day.

He left the hospital on the fourteenth postoperative day. He was readmitted to the hospital in July, 1948. The red blood count was again approximately 2,500,000 and there was again occult blood in the stool. In order to bring his blood again to normal a transfusion was given. Following this his temperature rose to 107° F., he became stuporous and anuric and died two days later in coma.

An autopsy was obtained. This revealed the esophagus well healed and the lumen adequate. There was no true area of bleeding found in the entire gastrointestinal tract.

The kidneys revealed some cloudy swelling but they were not the true picture of the anuric kidney seen after a transfusion reaction.

At the time this child had received his blood there had been some trouble in the local blood bank with blood which had been contaminated with a coliform bacillus. Such an organism was found in the heart blood and it was felt that the blood given may have contained this organism.

This child probably represents one of those persons who bleeds from the gastrointestinal tract but in whom no source of the bleeding is ever found.

The autopsy did reveal the esophageal stricture adequately cared for.

CASE 2.—P. M. was born in late 1946. Soon after birth some difficulty in swallowing was noted. She did, however, gain weight normally on a liquid diet and experienced no real trouble until solid foods were given. At approximately 18 months of age she entered the St. Mary's Hospital, Detroit. X-ray studies of the esophagus revealed a high-grade stricture in the lower one-third.

The child was well formed and normally developed. Laboratory findings with the exception of a mild secondary anemia were normal. Blood was given and the child was taken to surgery for correction of the esophageal lesion. She was given an anesthetic of ether and oxygen. Before the endotracheal tube was introduced, the child became pale and the pulse weak and thready. The anesthetic was stopped and the child recovered. The operative procedure was postponed and the child returned to the ward.

Five days later, at which time the child was perfectly normal, she was again taken to the operating room. This time anesthesia was induced without trouble. The chest was opened by resecting a portion of the left eighth rib. The mediastinum was opened and the esophagus raised up, and the stricture was identified.

The esophagus was resected above and below the stricture and the cut ends were united with interrupted silk sutures in two layers. A tube was left in the chest and connected to a closed drainage bottle.

The postoperative course was uneventful. Liquids were started on the second postoperative day. These were increased and on the fifth postoperative day the diet was changed to a normal one for the child.

On the evening of the seventh postoperative day, while the nurse was feeding her, the child suddenly and without warning died.

An autopsy was performed. No cause of death was found. The esophagus was well healed and there was no evidence of leakage.

Whether this was one of those peculiar instances of sudden death in children, the cause of which is never clear, cannot be said. It can be stated that the autopsy, except for healing of the esophagus, was not informative.

The patient had a well-healed esophagus at one week and there was no evidence of leakage. The child had been taking a normal diet for two days at the time of her sudden death.

CASE 3.—Another fatality occurred in a 70-year-old man who died approximately ten days after surgery. Death was due to a cerebral accident and no autopsy was obtained. However, esophageal function was good and there was no clinical evidence of leakage.

CASES 4 AND 5.—The two remaining patients have good esophageal function at this time and had a smooth and uneventful postoperative course. Their esophageal function remains adequate at this time, which is approximately eighteen months following surgery.

It is unfortunate that the fatality figures here reported are as high as they are, but it is gratifying that necropsy was obtained in two and that in each instance there was evidence of good healing.

DISCUSSION

The procedure described in this paper will not be of use in malignant lesions of the esophagus. In such patients the amount of esophagus to be resected would be too extensive and the procedure of esophagogastrostomy is the only feasible approach. However, it does appear to have a definite place in the short esophageal stricture. It appears from the foregoing results that blood supply of the esophagus is adequate to withstand this operative procedure and that healing will occur. Recently we have carried out a group of experiments in our laboratory which show that in the dog at least the esophageal blood supply is adequate when all the esophageal and gastric vessels with the exception of the right gastric are tied.

CONCLUSION

The resection of a short esophageal stricture with an end-to-end anastomotic repair is feasible.

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DISCUSSION ON "AN EXPERIMENTAL STUDY OF THE BLOOD SUPPLY OF THE ESOPHAGUS AND ITS RELATION TO ESOPHAGEAL RESECTION AND ANASTOMOSIS" BY DR. JOHN L. SHEK, DR. CARLOS A. PRIETTO, DR. W. M. TUTTLE, AND DR. E. J. O'BRIEN*; AND "THE TREATMENT OF SHORT ESOPHAGEAL STRICTURES BY RESECTION AND END-TO-END ANASTOMOSIS" BY DR. W. M. TUTTLE AND DR. J. C. DAY

DR. JOHN R. PAINE, Buffalo, N. Y.—Some of us at Buffalo General Hospital are engaged in a series of experiments very similar to those shown in the first paper. Our experience up to the present time confirms entirely the results Dr. Shek has shown you. We have carried the devascularization of the upper gastrointestinal tract to the extent of freeing entirely from its blood supply the cervical esophagus, the esophagus in the chest, and the stomach down as far as the right gastric artery and the right gastroepiploic artery. I would like to show a few slides of some of the specimens we have obtained. (Slides.)

In three dogs the entire thoracic esophagus was freed from its bed and its segmental blood supply severed. The esophagus was then cut transversely in middle third and resutured. No gangrene resulted. Healing of the anastomosis was satisfactory.

In two animals treated similarly, the anastomosis was made at about the junction of the lower and middle thirds of the esophagus. In two additional animals the anastomosis was placed at the junction of the upper and middle thirds. Healing was satisfactory in all these animals without gangrene.

*See page 523 for article by Shek, Prietto, Tuttle, and O'Brien.

The thoracic and cervical esophagus in two dogs was devascularized without resulting necrosis, but in another animal, operated upon in a similar fashion, gangrene of a portion of the distal segment occurred following transection and anastomosis in the cervical segment.

In two dogs the stomach was delivered into the chest and the esophagus transected 4 inches proximal to the cardia. A portion of the esophagus proximal to the transection was then excised and an anastomosis made to re-establish continuity. Healing was excellent without gangrene.

In four dogs the stomach was delivered into the chest, transections of the esophagus were made 4 to 7 inches proximal to the cardia, and after excising part of the thoracic and cervical esophagus proximal to the transection, anastomoses were made in the neck. In one animal gangrene occurred immediately distal to the suture line.

All intrathoracic procedures were performed through the right pleural cavity.

DR. E. F. PARKER, Charleston, S. C.—We wish also to confirm the experimental observations reported in the first paper. In a series of dogs we were able to resect an average of 33 per cent of the total length of the thoracic esophagus in the dog with a high percentage of success without the use of any adjunctive therapy whatsoever. In the dogs that recovered, some of whom were followed as long as eight months, there was a stricture in only one case. As Dr. Paine mentioned, in several of the other dogs there was dilation of the esophagus proximal to the site of anastomosis without any demonstrable stricture, and we thought this might be due to some neurologic disturbance. We have not had the opportunity to use the operation for benign stricture, to which, of course, it is ideally suited, but we have used it in two cases of carcinoma of the esophagus as a palliative procedure in an attempt to restore swallowing. These were both cases with extension of the carcinoma beyond the point of curability in the field of operation.

The first case was a woman with metastatic carcinoma of the mediastinum and the esophagus, secondary to a carcinoma of the breast removed seven years previously. It was a miserable failure because of disruption of the anastomosis, concomitant invasion of the trachea, and she soon developed an esophagotracheal fistula. In the second case, however, the function of swallowing was restored entirely to normal for a period of three months, at which time the patient developed recurrence of carcinoma at the site of anastomosis. However, the palliative restoration of swallowing definitely made it worth while even though carcinoma did return. Every time an artificial opening is made in one of these patients as a method of presumed palliation, it just adds to their troubles. We are all aware of that but it is well exemplified by a case we had several years ago when a Negro man was treated by the Thorek operation. He got along nicely but of course he had two artificial openings. About six months after operation when he looked very fine, I asked him if he had gone back to work. He said yes, and I asked what he was doing. He said, "It's a twenty-four hour a day job just looking after these two holes."

So if swallowing can be restored in these people without the production of any artificial openings, it is well worth while.

DR. HERBERT MAIER, New York.—I should like to present a case in which resection and end-to-end anastomosis of the esophagus has been utilized as a palliative procedure for a small carcinoma at the junction of the middle and lower third of the esophagus. This patient had metastatic disease which fixed the posterior wall of the stomach to the celiac axis, and it was not possible to free the stomach without transversing this mass. An esophagogastrostomy was therefore not feasible, but by leaving the distal part of the esophagus below the carcinoma attached to the stomach, continuity could be re-established. About 6 or 7 cm. of the esophagus with the small stenotic cancer were removed, and a careful end-to-end esophagoesophagostomy without tension was performed. The operation was performed about one-half a year ago. Roentgenograms show good function of the esophagus with no stenosis at the site of the anastomosis. The patient can swallow well but is now having increasing discomfort due to the intra-abdominal metastases.

DR. JAMES M. MASON III, Birmingham.—Dr. Tuttle mentioned the technique of longitudinal incision with plastic reconstruction of short benign esophageal strictures. This technique, we believe, will have a place in some such cases. I would like to present the following case history. (Slides.)

Jefferson-Hillman Hospital, No. 40188.—L. N., colored man, married, aged 46 years, was admitted to the hospital on Jan. 24, 1947, with a stricture high in the cervical esophagus which followed the accidental swallowing of lye four weeks previously. Attempts at dilatation were unsuccessful, and on Jan. 31, 1947, a gastrostomy was performed. He was discharged on February 8, and was readmitted on March 12, weighing 114 pounds. He was experiencing difficulty in maintaining adequate nutrition by gastrostomy feedings. On March 26, the cervical esophagus was exposed through an incision on the left side of the neck parallel to the anterior border of the sternocleidomastoid muscle. The strictured area, measuring about one inch in length was incised longitudinally; a nasal tube was passed into the esophagus through the stricture, and into the stomach, where the distal end was brought out through the gastrostomy opening. A string was attached to the lower end of the nasal tube and was pulled through the strictured area and out of the mouth. The tube was then removed and a bougie was placed within the strictured area and anchored by a string attached to each end. The wound was closed in two layers over the bougie. Gentle traction on the string gave early motion to the bougie and prevented the formation of adhesions in the divided strictured area. The wound healed per primum, and the bougie was removed. It was not necessary to continue dilatations during his stay in the hospital. He was discharged on May 2, 1947, with adequate esophageal lumen and had gained in weight from 114 to 145 pounds. He has been followed at intervals and the esophageal lumen continues adequate. When examined on Aug. 29, 1948, he weighed 150 pounds, and stated that he could eat anything he desired.

DR. WILLIAM E. ADAMS, Chicago.—I wish to congratulate Dr. Tuttle and Dr. O'Brien and their group for their demonstration of further advance in this field of surgery. Because of what has been told you by others, I will not go into all the experiments that we have done in this field only to say that our experience supports the thesis that the blood supply of the esophagus is far better than had been anticipated from earlier work. Our experiments might be divided into three groups which I shall mention briefly: One, in which mobilization of the entire thoracic esophagus and division of the left gastric vessels without resection resulted in no deaths from necrosis due to lack of blood supply. A number of these animals died, and it was because of pylorospasm through injury to the vagus. I think that probably explains some of the problems presented here, namely, dilation of the stomach and esophagus. In another group of dogs various lengths up to 6 and 7 cm. of the thoracic esophagus were removed, with primary end-to-end anastomosis. In these animals a liquid diet was given immediately following operation, and no chemotherapy or antibiotics were used. There were no deaths. In the last group of experiments, which are still under way (Dr. Fritz, my associate, is still working on this), the entire thoracic esophagus up to the cervical region is mobilized and brought out through the neck. As much as 6 or 7 cm. of the esophagus is removed and an end-to-end anastomosis made. Of these cases (there are only a few so far), one-third have survived and are getting along well, in spite of the fact that all the blood supply is coming from the left gastric artery.

DR. RICHARD SWEET, Boston.—We have had ample evidence this morning, both experimental and clinical, that localized segments of the esophagus can be resected. I would like to say a few words about what I consider to be the probable limitations of this method as applied to clinical cases, particularly in two diseases. First is the localized stricture which Dr. Tuttle so successfully treated in two of his patients. This is, of course, a relatively rare condition at best and, in my experience, is a somewhat treacherous one from the standpoint of results. Sometimes there seems to be a tendency to recurrence of esophagitis, which is the primary lesion in these cases, just above or close to the anas-

tomotic site. I would venture to predict that, when rather limited segments are removed in this disease, there will be some functional difficulty from recurrence of the same process in certain cases.

The other matter has to do with the localized excision of carcinoma of the esophagus. Of course we all know that this disease is extremely malignant and has a tendency to propagate in the submucosal layers and to extend a long distance beyond the obvious tumor. I doubt, therefore, that this method of local excision will ever have any great application as a means of palliation. I would think that the experience of Dr. Parker, who mentioned that his patient survived for three months before swallowing difficulty recurred, would be the one more apt to be experienced than that of Dr. Maier, whose patient has gone for six months. I doubt whether three months palliation would make it worth while to subject a patient to an operation of such magnitude as this.

DR. JOHN H. GIBBON, JR., Philadelphia.—The blood vascular studies, which have been made in dogs demonstrating the adequacy of the arterial circulation when the short vessels to the esophagus are interrupted, cannot be interpreted as applying to the human esophagus. I agree with Dr. Sweet that probably end-to-end anastomosis of the esophagus will have very little application in humans. I think a study of the blood supply of the human esophagus would be of great value and would apply to those patients in whom an extensive exploration has resulted in interruption of most of the arterial branches to the esophagus in the thorax. I am sure it has been the experience of many of you that you have explored such patients and interrupted a great deal of the blood supply. I have had such experience and fortunately, or perhaps it is the general finding, the patient has not developed gangrene of the esophagus. Arteriograms made in fresh cadavers, studying the anastomotic channels between arterial vessels in the thoracic esophagus, would be of considerable interest. Such injection studies in cadavers, it seems to me, would be more valuable than studies of the esophageal blood supply in different species.

DR. W. EMORY BURNETT, Philadelphia.—Although we are not advocating end-to-end resection of the esophagus for carcinoma, I would like to mention two cases in which Dr. Rosemond, Dr. Cooke, and I did apply that method to carcinoma. I thought it might be worth while to call to your attention these two cases. The first was a pedunculated tumor of 2 to 3 cm. in size on which esophageal biopsy was reported as probably a sarcoma, so that we did approach this from the right side where easy access could be obtained, and did resect locally a distance of about 6 cm. with end-to-end anastomosis. The operative specimen was a pedunculated carcinoma, not sarcoma. That patient has gone more than one year now without symptoms and without evidence of recurrence. The second one was a very small carcinomatous lesion in which we again applied this method of excision and were pleased that the microscopy of the ends of this resected specimen showed no evidence of carcinoma. However, about three months after this the man developed stenosis and of course was thought to have a recurrence. We pushed our luck and again explored this. Because I thought it was not recurrence, we did a very local resection of 2 cm. with frozen section. There was no evidence of carcinoma in this benign stricture. But this patient did not survive the second resection. It was probably poor judgment, to again do end-to-end anastomosis. Those two cases have been our experience with this particular maneuver.

DR. EDWARD D. CHURCHILL, Boston.—Before asking Dr. Prietto to close, I wish to make one general comment because I recall so vividly the bitter resentment that is awakened in a young experimentalist when older surgeons tell him that what he does on the dog is not applicable to the human being. This is because so frequently such a criticism arises from prejudice and ignorance. I would call attention to the fact that Dr. Gibbon is an experienced mammalian experimentalist; yet he made that very familiar remark. If he had not made it I think I would have been inclined to do so, perhaps somewhat more gently. But, knowing the feeling the young surgeon has when such a statement is made,

it is perhaps worth while to comment on it. The validity of the criticism depends entirely on the question the experiment is designed to answer and the conclusions that are drawn from it.

Dr. Prietto's work is an interesting study of the comparative anatomy of the esophagus of the dog, in which the healing of the tissue is employed as an experimental method. Those of us who keep dogs as pets know full well how they eat, how they bolt their food, and crack and swallow bones. In the dog, the esophagus seems more nearly part of the stomach than it is a specialized conducting tube. The function of the esophagus in the dog, as contrasted with that of man, needs interpretation. Again, the dog has no mediastinum in the sense that the human has. For many years battles were fought on the floor of this Association between the thick pleura animal experimentalists and the thin pleura animal experimentalists. The dog is a thin pleura animal; perhaps he has a "thin pleura esophagus." I hope that Dr. Prietto will not be discouraged. It is only the interpretations that are likely to be drawn from his work that are being challenged by Dr. Gibbon.

DR. PRIETTO.—I wish to thank, on behalf of Dr. Shek and myself, Dr. Churchill and the others who discussed this paper for their kind remarks. Our experiments go only one step at a time; where they will end nobody knows. In addition, may I say, to corroborate the discussions of Dr. Paine and Dr. Parker, I did not mention that in our experiments we did save the vagus, as much as possible without trauma. That might be the explanation, as they concluded, for the dilation of the stomach in one of their dogs which died.

DR. TUTTLE.—I want to thank the discussants. I, too, do not feel that this procedure will ever replace to any great extent the operation of esophageal resection and subsequent esophagogastrostomy. I present this only because it was an interesting observation, because it has worked in these individuals, and because it has not, so far as I know, been previously reported to have been a successful procedure.

In answer to Dr. Sweet, there are two types of lesions which occur in the esophagus which produce strictures and in which there is no previous history as to the true nature of the stricture. We feel that probably one of these things is a peculiar type of esophagitis and I agree that this type of lesion must be resected fairly widely. Two of our patients, I think, had that type of lesion. The second type of lesion was seen in two children. These lesions were probably one of the congenital weblike diaphragms which one sees in children not infrequently. In such lesions, due to the manipulation which is carried out before resection is thought of, there frequently develops a certain amount of esophageal infection, which tends to produce stricture as time goes on.

In answer to Dr. Barnett's comment; I think that probably these are best approached from the left side, because if it becomes apparent that a local resection cannot be done, one might have considerable difficulty from a right-sided approach. Another point is that in the esophageal strictures it is sometimes very hard to tell the exact length by palpation.

In answer to Dr. Gibbon I would like to say that these experiments were done only to demonstrate the blood supply in the dog. Nothing was said about the blood supply in the human esophagus. It was an experimental study on the dog, and the conclusions have been drawn only from the dog. However, it is interesting that healing has occurred, because if one goes back to the older experimental literature it will be found that local resection and end-to-end anastomosis, also in the dog, done fifteen or twenty years ago, almost routinely failed. So I believe these experiments do have a certain amount of merit. We agree with Dr. Gibbon that the studies should be carried further on human beings and in fresh autopsy specimens, and that is our plan. This report was only the first step in a general plan to study the blood supply of the esophagus.

ACQUIRED NONMALIGNANT ESOPHAGOTRACHEOBRONCHIAL FISTULA

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THE successful surgical treatment of 4 patients with acquired nonmalignant esophagotracheobronchial fistulas prompted a consideration of the incidence, clinical features, and management of this disease.

We have located in the literature of the past thirty-two years (1916 to 1949) 75 cases of acquired nonmalignant fistulas. Only 6 of these cases were treated by direct surgical repair,[1, 2, 3, 4, 7, 9] although Poncet[11] established the feasibility of this method of treatment in 1896. He successfully closed by curretage and suture through a transtracheal approach in the neck a fistula caused by actinomycosis. The infrequent occurrence of acquired nonmalignant esophagorespiratory fistulas and the paucity of operative cases have led to the accumulation of meager experience by any individual in the management of this disease. We have extracted certain pertinent information from the 75 case reports which we believe will lead to a more comprehensive knowledge of the subject as well as more defined indications for surgical treatment.

The anatomic relationship of the larynx, trachea, and left-stem bronchus to the esophagus is conducive to the development of fistulas. At its commencement the esophagus lies in the midline, but it inclines to the left side as far as the thoracic inlet and gradually passes to the midline again at the level of the bifurcation of the trachea. The esophagus lies in immediate contact with the membranous portion of the trachea and the left-stem bronchus. This relationship may explain previous observations that malignant and nonmalignant esophagorespiratory fistulas more frequently communicate with the left-stem bronchus than the right. Our analysis of the reported nonmalignant acquired variety has yielded 44 case reports in which the location of the fistula was stated (Fig. 1). In this group the right-stem bronchus was involved more often than the left. The deep cervical, paratracheal, and tracheobronchial groups of lymph nodes lie in immediate contact with the esophagus, trachea, and major bronchi, and may play an important role in the pathogenesis of fistulas of infectious origin.

ETIOLOGY

Fifty to 60 per cent of acquired communications between the esophagus and respiratory tract are caused by malignant lesions.[10, 12] Acquired nonmalignant esophagorespiratory fistulas may best be classified on the basis of etiology (Table I). In an analysis of 75 reported cases, trauma was found to cause the fistula in approximately 1 out of 3 patients (Table II). The most common causes of traumatic fistulas were respiratory or esophageal foreign bodies,

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instrumental dilatation of benign strictures of the esophagus, and severe crushing wounds of the thorax (Table III). There seems to be a correlation between the traumatic agent and the site of communication of the fistula with the respiratory tree. The fistulas caused by compression injury of the thorax communicated with the trachea in 3 out of 4 patients, while those caused by foreign bodies and instrumentation of esophageal strictures communicated with either the right- or left-stem bronchus in 7 of 8 patients.

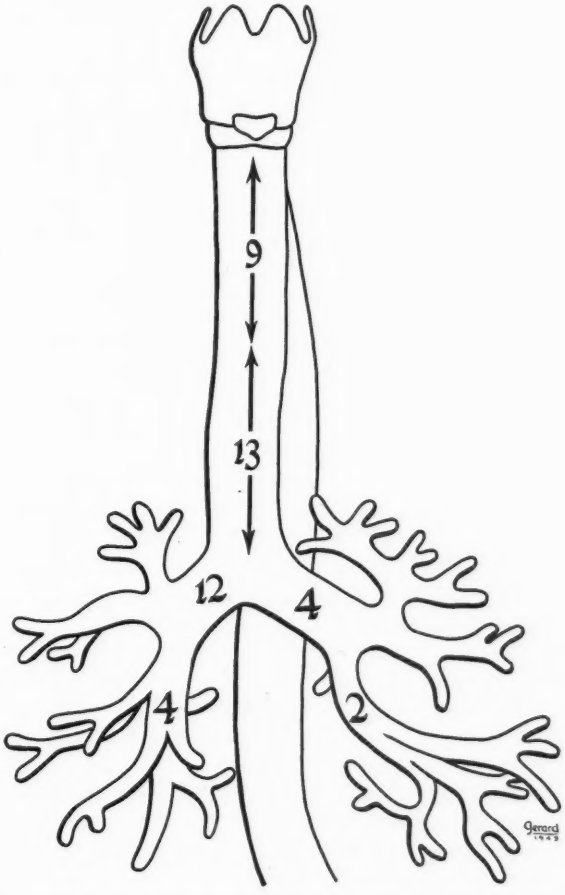

Fig. 1.—Anatomic location of 44 reported cases of esophagotracheobronchial fistula.

Infection was the most common cause of esophagorespiratory fistulas. In a study of the 75 reported cases of nonmalignant fistulas, 26 were known to be caused by a specific type of infection (Table II). Although in 16 additional cases the etiology of the fistula could not be determined by the history, physical

TABLE I. CLASSIFICATION OF ESOPHAGOTRACHEOBRONCHIAL FISTULAS

I. Congenital
II. Acquired
A. Malignant
B. Nonmalignant
1. Traumatic
a. Foreign body
b. Instrumentation
c. Wounds of thorax
d. Chemical (ingestion caustics)
2. Esophageal diverticulum
3. Infection
a. Tuberculosis
b. Syphilis (gumma or aneurysm)
c. Fungus
d. Nonspecific

findings, and frequently by pathologic examination of excised tissue, it seems likely that many of these resulted from pre-existing mediastinal infection of a nonspecific character. Tuberculosis and syphilis are the most frequent specific infections which lead to fistula formation. Tuberculosis of the esophagus is a rare disease. We have not observed ulcerative tracheobronchial tuberculosis to lead to fistulous communication with the esophagus in the absence of mediastinal tuberculous lymphadenitis. The pathogenesis of tuberculous fistulas is best

TABLE II. ETIOLOGY OF SEVENTY-FIVE REPORTED CASES OF ESOPHAGOTRACHEOBRONCHIAL FISTULA*

Traumatic	21
Undetermined	16
Tuberculosis	14
Diverticulum of esophagus	11
Syphilis	11
Empyema	1
Actinomycosis	1

*Includes authors' 4 cases.

explained on the basis of either erosion of caseating or calcified lymph nodes, or rupture of cold abscesses into the tracheobronchial tree and esophagus. Syphilis may involve any part of the respiratory tract or esophagus, and in its tertiary stage may produce fistulas by necrosis and ulceration of gummata. Aneurysms less frequently lead to fistula formation by pressure necrosis.[6] Two case reports of esophagorespiratory fistula caused by actinomycosis appear in the literature.[11, 13]

Traction diverticulum of the esophagus was responsible for fistula formation in 11 cases. Although traction diverticula can usually be attributed to pre-existing periesophageal infection with subsequent contraction of scar tissue,

TABLE III. ETIOLOGY OF TWENTY-ONE REPORTED CASES OF TRAUMATIC ESOPHAGORESPIRATORY FISTULA

Foreign body	4
Dilatation stricture esophagus	4
Nonpenetrating wound	4
Penetrating wound	2
Operative	2
Chemical (lye)	1
Incomplete data	4

it is not always possible to identify the initial infection. Traction diverticula may lead to fistulous communication with the respiratory tree by continued activity of the initial infection responsible for the diverticulum, by superimposed secondary infection, and by erosion of calcified lymph nodes. The exact location of the opening of the fistula into the respiratory tree was given in 9 of the 11 reported cases of this type. In 7 of these the esophagus communicated with a secondary bronchus, usually the lower lobe, and in 2 the stem bronchus.

CLINICAL FEATURES AND DIAGNOSIS

Symptoms of this disease deserve emphasis. Four cases herein reported were under observation for periods ranging from ten months to eight years without benefit of a correct diagnosis. The development of a communication between the respiratory system and the esophagus invariably leads to characteristic symptoms. The ingestion of fluids is followed by strangling or severe paroxysms of coughing after a momentary asymptomatic pause. In large fistulas solid foods produce the same symptoms and large particles of ingested food may be coughed up. Chronic cough, upper respiratory infections, and repeated attacks of pneumonia are of common occurrence. The fistula may lead to the development of lung abscess or bronchiectasis. Hemoptysis is not an unusual symptom and it may terminate in death.[10] Large fistulas may be associated with severe weight loss. Some patients become accustomed to the inconvenience of the fistula and suffer little interference with nutrition. Many learn the advantage of swallowing in the dorsal recumbent position which tends to minimize the typical paroxysmal attacks of coughing and strangling (Ono's sign).[8]

The diagnosis of esophagorespiratory fistula is based upon the history, physical examination, roentgenographic studies, and endoscopic examinations. Trauma to the chest, ingestion of foreign bodies or caustics, and instrumentation of the esophagus may be followed immediately or later by characteristic symptoms of fistula. Long-standing communications between the esophagus and respiratory tree are usually nonmalignant. Fistulas of short duration in the cancer age group are suggestive of malignant lesions. If dysphagia precedes the development of symptoms of esophagorespiratory communication, it is indicative of cancer of the esophagus. A fistula of tuberculous origin may be preceded by a protracted and indefinite illness (Case 3).

Physical examination may reveal evidence of tuberculosis, syphilis, or mycotic disease. Clinical signs of respiratory tract infection may consist of the presence of moist râles over a lobe or signs of advanced suppurative disease of the lung. Physical signs of pulmonary infection are not always present. A fistula does not invariably lead to chronic suppurative disease of the lung, for the 4 cases herein reported showed no evidence of permanent changes in the tracheobronchial tree. It is possible to demonstrate the fistula in some cases by detecting the appearance of râles in the lungs after the ingestion of water (Ono's sign).[8] Roentgenographic studies consist of a routine posterior-anterior film of the chest, roentgenograms following the ingestion of contrast media, and bronchograms. Frequently, barium sulfate is administered prior to establishment of the diagnosis; however, ingestion of iodized oil is preferable in that

it is less irritating to the tracheobronchial tree. Suitable roentgenograms and fluoroscopy following ingestion of opaque oil will usually delineate the course of the fistulous tract. Esophagoscopy reveals the fistula to lie usually in the anterolateral wall of the esophagus. The opening may be easily overlooked due to its slitlike configuration. A bechic blast can be felt when the tip of the esophagoscope is proximal to the orifice of a large fistula. Biopsy is indicated in papillomatous and ulcerative lesions. Bronchoscopy is of value in confirming the communication of the fistulous tract with the respiratory tree. The opening of the fistula lies in the membranous wall of the trachea or bronchus. It may not be possible to visualize the orifice of the fistula in a secondary bronchus; however, it can be localized by injecting methylene blue solution into the esophagus during bronchoscopy. The colored solution may be observed to well up into the involved segmental bronchus. Bronchiectasis must be excluded by adequate bronchograms as its presence alters the surgical treatment of esophagorespiratory fistulas.

TREATMENT

Careful analysis of the 75 reported cases of fistula shows that two-thirds of the patients received no specific treatment. In the group of 53 patients untreated by surgery the outcome was stated in 26; 16 died while hospitalized, 6 showed no improvement, and 4 were cured (Table IV). The results in 22 cases treated by surgery are extremely gratifying. Fifteen of the 22 patients were cured, 3 died, and 4 showed no improvement (Table V).

TABLE IV. NONSURGICAL TREATMENT IN FIFTY-THREE REPORTED CASES OF ESOPHAGOTRACHEOBRONCHIAL FISTULA

	NUMBER OF CASES	RESULTS			
		NOT STATED	CURED	UNCHANGED	DIED
1. No specific treatment	45	27	1	4	13
2. Antisyphilitic therapy	7	0	2	2	3
3. X-ray therapy	1	0	1	0	0
Total	53	27	4	6	16

The treatment of traumatic esophagorespiratory fistulas requires consideration of the time interval following injury. Acute traumatic fistulas associated with infection or extensive mediastinal emphysema may require external surgical drainage of the mediastinum. Few patients will be seen sufficiently early to warrant immediate operative closure of the fistula because of diagnostic difficulties and the relatively short period of wound contamination.

Fistulas associated with gummatous ulceration of the esophagus or tracheobronchial tree should receive vigorous antisyphilitic therapy. If there is proved or presumptive evidence of tuberculosis in a granulating fistulous tract, recent experience suggests that a preliminary course of streptomycin may be of value. Clerf[5] has shown that it is possible to close small fistulas (3 mm. or less in diameter) by endoscopic cauterization with silver nitrate or sodium hydroxide. Fistulas complicated by bronchiectasis or lung abscess may require pulmonary resection regardless of the site of communication of the fistula with the tracheo-

TABLE V. SURGICAL TREATMENT IN TWENTY-TWO REPORTED CASES OF ESOPHAGOTRACHEOBRONCHIAL FISTULA

	NUMBER OF CASES	RESULTS		
		CURED	UNCHANGED	DIED
1. Cauterization (endoscopic)*				
A. Chemical	4	3	1	0
B. Electric	1	0	1	0
Total	5	3	2	0
2. Direct surgical repair†				
A. With preliminary gastrostomy	4	4	0	0
B. Without preliminary gastrostomy†	6	5	0	1
Total	10	9	0	1
3. Pulmonary resection and closure of esophageal defect	2	1	0	1
4. Palliative gastrostomy	3	0	2	1
5. Drainage of coexisting lung abscess	2	2	0	0
Over-all Total	22	15	4	3

*All small fistulas.
†Includes authors' 4 cases.

bronchial tree. It is always necessary to close the defect in the esophagus, whereas the site of communication of the fistula with the respiratory tree may be removed with the resected lobe or lung.

Preoperative preparation of the patient consists of correcting protein depletion, vitamin deficiencies, and anemia, and of restoring the contracted blood volume. Although serious states of nutritional deficiency may exist, we have not found it necessary or desirable to perform a preliminary gastrostomy. Positive nitrogenous balance can be attained in the patient with a large fistula by means of gastric gavage through an indwelling Levine tube. If necessary, this may be supplemented by parenteral nutritional therapy. A survey is made of the cardiac and renal functions. Preoperatively, intramuscular and aerosol penicillin is administered for a period of three or more days. We believe the physical state of the fistulous communication will prove with further experience to be of paramount importance. Smooth epithelized communications are suitable for immediate and direct surgical closure. Small fistulas and fistulas associated with exuberant granulation tissue should receive local cauterization and antibiotics in expectation of cure or alleviation of the local infection preparatory to later surgical treatment.

Caldwell[3] has directed attention to the problems of anesthesia in acquired communications of the esophagus with the respiratory tree. Large fistulas communicating with the trachea are of little concern to the anesthetist providing there is sufficient space for the insertion of an inflatable balloon between the carina below and the fistulous orifice above (Case 4). If the fistula in the terminal trachea does not permit the interposition of a balloon between it and the carina, a snugly fitting intratracheal tube without a balloon will likely prove satisfactory.[3] We have had no difficulty with routine intratracheal intubation anesthesia when the fistula communicated with a stem bronchus or secondary bronchus.

Direct surgical repair of an acquired esophagorespiratory fistula requires a cervical, cervical combined with anterior mediastinal, or transpleural approach. Fistulas located in the region of the superior thoracic aperture require a cervical approach combined with either a median sternotomy (Case 4) or resection of the inner third of the clavicle and the anterior portion of the upper two ribs. The esophagus is mobilized above and below the fistulous communication with the respiratory tree. The fistulous tract is divided and if of sufficient length a portion is excised. The defects in the esophagus and trachea or bronchus are closed by one of the conventional methods of suture. We prefer to close the trachea or bronchus with two layers of interrupted 000 silk sutures, a proximal longitudinal mattress suture, and a distal simple on-end suture. The esophageal defect is closed in a transverse plane using two rows of interrupted 000 silk sutures. Simple through and through sutures approximate the walls of the defect and the knots are tied within the lumen of the esophagus. The second layer consists of mattress sutures which approximate the muscular wall over the first layer of sutures (Fig. 2). The repaired defects are protected by the interposition of adjacent tissue.

The postoperative care consists of detailed attention to evacuation of tracheobronchial secretions, removal of the intercostal drainage tube in forty-eight hours (transpleural operation), parenteral penicillin and streptomycin, general supportative measures, and fluids by mouth on the seventh postoperative day.

The following case reports demonstrate the successful surgical treatment of 4 patients with esophagorespiratory fistulas.

CASE REPORTS

CASE 1.—During the early part of November, 1936, E. J., a white woman, 18 years of age, aspirated a small nail into the trachea. An illness followed characterized by severe coughing attacks, high temperature, and production of purulent sputum. A diagnosis of pneumonia was made and after a period of two weeks a bronchoscopist was consulted who failed to find the foreign body. An x-ray film at this time showed the nail to lie in the region of the left-stem bronchus. The fever gradually subsided but she continued to cough, and one month later a second bronchoscopic examination was carried out. This examination showed an ulceration on the posterior wall of the left-stem bronchus. The foreign body was no longer visible in the roentgenogram. Two months after aspiration of the foreign body she began to cough and strangle on the ingestion of liquids. She suffered from three distinct attacks of pneumonia in the lower lobe of the left lung during the ensuing five years. She had been unable to gain weight but complained very little of her symptoms other than strangling and coughing on the ingestion of fluids.

The physical examination revealed an undernourished woman who appeared chronically ill. There was suppression of breath sounds at the left base. The hemoglobin was 72 per cent and the red blood cell count was 3,500,000. The total and differential white blood cell counts were normal. The blood serology was negative. A roentgenogram of the chest showed partial obliteration of the left costophrenic sulcus. Bronchoscopic examination revealed a slitlike defect in the left-stem bronchus 1 cm. below the carina. The fistulous orifice was approximately 1 cm. in diameter in its long axis and there was no associated inflammation. Instillation of colored water into the esophagus at the time of bronchoscopy showed a communication to exist between the esophagus and left-stem bronchus. Esophagoscopy confirmed the presence of a well-epithelized esophagobronchial fistula. After ingestion of Lipiodol

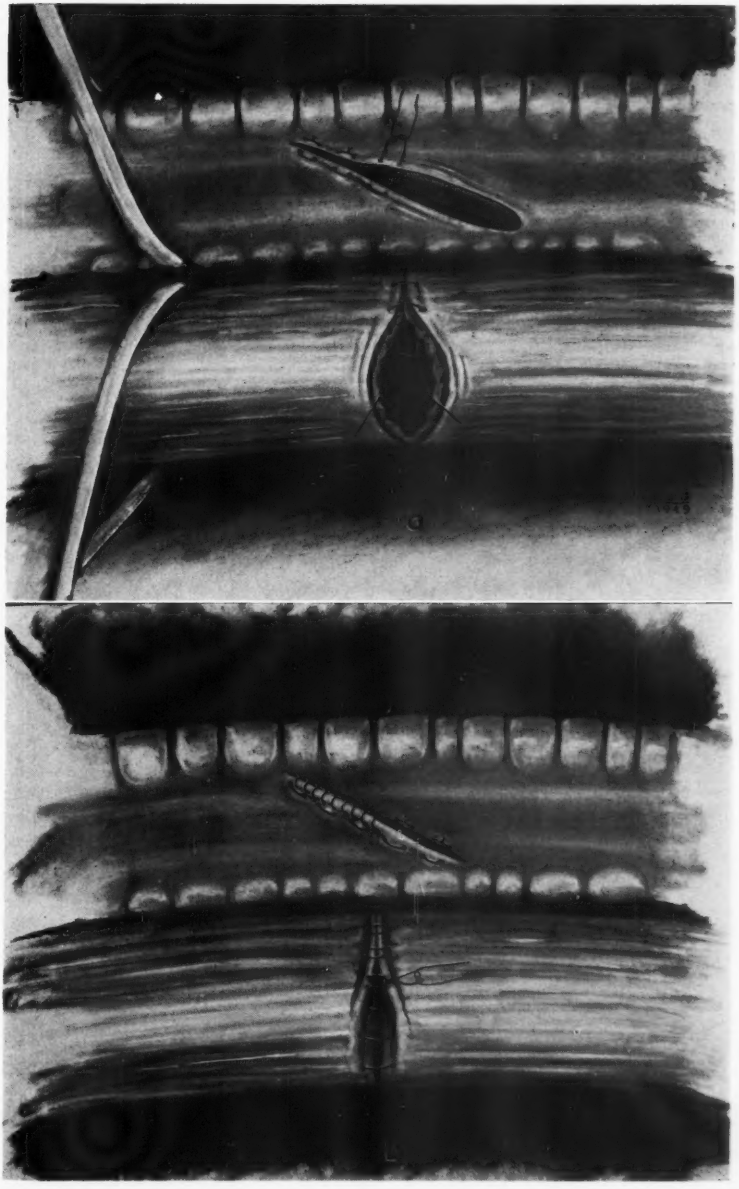

Fig. 2.—Esophageal and tracheal defects following division of fistula (Case 4). *a*, First row of interrupted 000 silk sutures. *b*, Second row of interrupted 000 silk sutures.

an excellent bronchogram was obtained in that the opaque oil readily entered the left-stem bronchus. The oil filled both the left and right lower lobes and the bronchial pattern was normal.

On Nov. 12, 1941, a left thoracotomy was performed and the esophagus was mobilized above and below its fistulous communication with the left-stem bronchus. A segment of the fistulous tract was excised and the defects in the bronchus and esophagus were both closed with two layers of 000 silk sutures. Sulfadiazine was administered for a period of three days preoperatively and for twelve days postoperatively.

The pathologist reported a tubular structure lined by stratified squamous epithelium.

Convalescence was uneventful and the patient was discharged from the hospital on the twenty-first postoperative day. The patient has remained entirely asymptomatic and there has been no evidence of recurrence of the fistula during the past seven years.

Comment.—A white woman, 18 years of age, with a traumatic esophagobronchial fistula 1 cm. in diameter and of five years' duration has been cured by resection of the fistulous tract and closure of the esophageal and bronchial defects.

CASE 2.—W. S., a 46-year-old white man, had a nine months' history of paroxysms of coughing and strangling on ingestion of liquids or solids. In February, 1946, he inadvertently swallowed a chicken bone. Seventy-two hours after this incident he noted that the ingestion of liquids or solid food caused episodes of coughing. The symptoms persisted and three months later he coughed up a chicken bone about one-half inch in length. During the ensuing six months he continued to strangle and cough following ingestion of either liquids or solids, and he was unable to maintain a normal state of nutrition. There was a weight loss of thirty pounds.

The physical examination was not remarkable except for evidence of considerable weight loss and severe malnutrition. Rectal examination showed one plus enlargement of the prostate gland. The hemoglobin was 13 Gm. and the red blood cell count was 4,200,000. The total and differential white blood cell counts were normal. The sedimentation rate was 27 mm. the first hour. The blood serology was negative. Roentgenographic study following ingestion of Lipiodol showed the presence of a fistulous communication between the esophagus and left-stem bronchus. A roentgenogram of the chest was normal. Laryngoscopic examination revealed a papilloma of the right vocal cord but both cords exhibited normal function. Bronchoscopy revealed a small patch of granulation tissue on the posterior wall of the left-stem bronchus just below the carina. A dilute solution of methylene blue was instilled into the esophagus with the bronchoscope in place and immediately it was observed to appear in the left-stem bronchus. A diffuse tracheobronchitis was present and associated mucopurulent secretions were aspirated from the left bronchial tree. The communication with the esophagus could not be identified during esophagoscopy.

The preoperative preparation and observation of this patient extended over a period of three weeks. During this time he was repeatedly observed to cough up large particles of food during his meals. The fistulous communication clinically appeared to be much larger than indicated by bronchoscopic examination. It was necessary to supplement the high caloric, high protein diet by parenteral protein hydrolysates and blood transfusions. Intramuscular and aerosol penicillin was administered for a period of one week preoperatively because of associated tracheobronchitis.

On Jan. 3, 1947, a left thoracotomy was performed through the periosteal bed of the resected fifth rib with the patient under pentothal and endothracheal gas, oxygen and ether anesthesia. The esophagus was mobilized above and below its fistulous communication with the left-stem bronchus. The fistula was approximately 3 cm. in length and 1.5 cm. in diameter. The fistulous tract was divided between clamps and the defects in the esophagus and membranous portion of the left-stem bronchus were both closed by two layers of interrupted 000 silk sutures. Bronchoscopy performed immediately after closure of the thorax showed no encroachment on the lumen of the left-stem bronchus.

The pathologic examination of the fistulous tract showed it to be well epithelized and lined by squamous epithelium. There was no active inflammation present and no evidence of a specific inflammatory disease.

Intramuscular penicillin was administered for a period of ten days following the operation. On the seventh postoperative day he received fluids by mouth. There were no complications and he was discharged from the hospital on Jan. 22, 1947. He returned for a follow-up examination one month later, at which time he was entirely asymptomatic.

Comment.—A traumatic esophagobronchial fistula 1.5 cm. in diameter in a 46-year-old white man has been apparently cured by resection of the fistulous tract and closure of the esophageal and bronchial defects.

CASE 3.—In November, 1937, E. G., a 65-year-old white woman had what was thought to be a severe case of "influenza" characterized by low-grade fever, ease of fatigue, and loss of weight. This ill-defined state of health persisted for a period of eighteen months. In the early part of 1939 she noticed that ingestion of liquids initiated attacks of coughing and strangling; however, no difficulty was experienced with dry and solid foods. The symptoms showed no marked change until the time of her present hospital admission.

At the age of 43 years she was hospitalized for pulmonary tuberculosis. After a period of six months' observation she was discharged with apparently arrested tuberculosis. As a child she had rheumatic fever unattended by complications. Her father died of pulmonary tuberculosis when she was a child.

This patient was an elderly woman who appeared to be in good health. The physical examination was essentially negative except for moist râles in the lower lobe of the left lung. The hemoglobin was 80 per cent and the red blood cell count was 3,900,000. The total and differential white blood cell counts were normal. The blood serology was negative. The nonprotein nitrogen was 33 mg. per cent. The kidneys were able to concentrate to a maximum specific gravity of 1.015 during the Mosenthal concentration test. The phenolsulfonphthalein excretory kidney test was normal. The total serum protein was 7.6 Gm. per cent with a normal albumin-globulin ratio. The sputum was repeatedly negative for acid-fast bacilli. The urinalysis showed a one plus albumin with 75 to 100 white blood cells per high powered field. The electrocardiogram revealed abnormal P waves in Leads 2 and 3. The Q_3 and T_3 patterns suggested a residual of old posterior myocardial infarction. The vital capacity was 62 per cent of normal.

The preoperative studies and diagnosis in this patient were made* prior to the patient's hospital admission. A roentgenogram of the chest revealed findings compatible with healed bilateral pulmonary tuberculosis. After the ingestion of a contrast medium, fluoroscopy and suitable roentgenograms demonstrated a fistulous communication of the esophagus with a secondary bronchus of the left lower lobe. The lower lobes of both lungs were filled by the contrast medium and revealed no evidence of bronchial dilatation. The orifice of the fistulous tract could not be identified on bronchoscopic examination. Esophagoscopy showed the orifice of the fistula to be epithelized and to lie in the left anterolateral wall of the esophagus. She was given aerosol and intramuscular penicillin for a period of six days prior to operation.

On Nov. 19, 1947, a left thoracotomy was performed entering the pleural cavity through the periosteal bed of the resected seventh rib. The anesthesia consisted of pentothal and endotracheal gas, oxygen and ether. The upper lobe of the lung was found to be studded with numerous calcified nodules ranging in size from ½ to 1 cm. in diameter. There was partial symphysis of the visceral and parietal pleurae. Multiple calcified lymph nodes were encountered adjacent to the bronchi and in the mediastinum. There was a fistulous tract leading from the esophagus to the posterior segmental bronchus of the left lower lobe 1 cm. in diameter and 4 cm. in length (Fig. 3). The communication was eradicated by excision of 3 cm. of the fistulous tract and closure of the bronchial and esophageal defects as illustrated in Fig. 2.

*By Dr. George A. Welchons, Richmond, Va.

The pathologist reported that representative sections displayed a tubular structure with a central lumen lined by a broad zone of stratified squamous epithelium. The wall exhibited no evidence of an active inflammatory process. No tubercles were present.

Postoperatively, intramuscular penicillin was administered for a period of ten days. She developed atelectasis of the left lower lobe on the second postoperative day which was promptly relieved by intratracheal catheter aspiration. Seventeen days after operation she was discharged from the hospital. She has had no subsequent cough and no recurrence of symptoms during the past fourteen months.

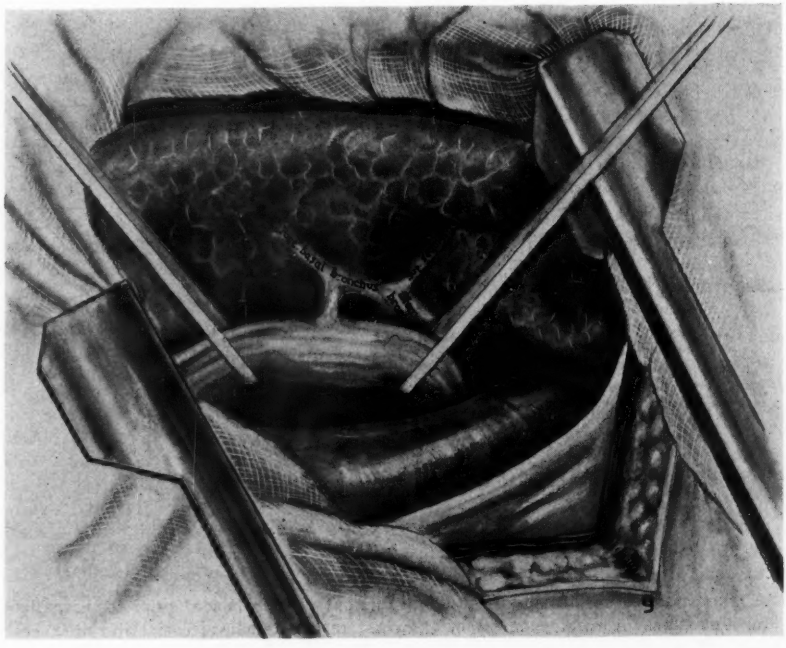

Fig. 3.—Fistulous communication between the esophagus and posterior basal segmental bronchus of lower lobe left lung (Case 3).

Comment.—This 65-year-old white woman had symptoms of an esophagobronchial fistula for a period of eight years. Coexisting healed pulmonary tuberculosis and calcification of tracheobronchial lymph nodes are presumptive evidence of the fistula's likely being tuberculous in origin, although pathologic examination of the excised fistula showed no tubercles. Excision of the fistulous tract 1 cm. in diameter with closure of the esophageal and bronchial defects resulted in an apparent cure.

CASE 4.—T. M., a 24-year-old white male student, developed "pneumonia" in August, 1944, accompanied by the simultaneous onset of pronounced strangling, choking, and coughing on the ingestion of either liquids or solid food. At the onset of the illness he also became hoarse. He recovered from the "pneumonia" after a period of one week but the associated symptoms persisted to the present hospital admission. He suffered from chronic cough unrelated to swallowing and frequently produced blood-streaked sputum. A second episode of pneumonia was experienced several months after the onset of his symptoms.

Over a period of four years he had lost a moderate amount of weight even though he had mastered an ingenious method of preventing food from entering the trachea during deglutition. He had noticed that holding his head slightly to the left and leaning backwards led to improved passage of food into the stomach rather than into the trachea.

There was evidence of moderate weight loss. A few transient râles were heard over the bases of both lungs. The physical examination was otherwise negative. The hemoglobin was 15.2 Gm. and the total and differential white blood cell counts were normal. The sedimentation rate was 21 mm. the first hour. The blood serology was negative. The first and second strength tuberculin skin tests were negative. The vital capacity was normal. The blood chemistry studies were normal. Roentgenographic studies after the ingestion of Lipiodol showed a fistulous communication between the esophagus and trachea at the level of the superior thoracic aperture (Fig. 4). Laryngoscopic examination showed paralysis of the left vocal cord. An ingested silk thread readily entered the trachea by way of the fistula and after being coughed up it was reswallowed. The string made two or three complete revolutions about the described circuit which required its piecemeal removal through a laryngoscope.

Bronchoscopy showed a large fistulous communication of the posterior wall of the trachea with the esophagus at the level of the superior thoracic aperture. The No. 840 bronchoscope could be passed easily into the esophagus by way of the fistulous tract. The fistula had a smooth epithelial lining and appeared to be greater than 3 cm. in diameter. The tracheobronchial tree showed severe and generalized purulent tracheobronchitis. Esophagoscopy showed the fistula to lie in the left anterolateral wall of the esophagus 23 cm. below the upper incisor teeth, and the 9 mm. esophagoscope could be passed through the fistula into the trachea.

The purulent tracheobronchitis required a prolonged preoperative period of aerosol penicillin and streptomycin and intramuscular penicillin. The sputum culture repeatedly showed *Escherichia coli*. It was possible to maintain his nutritional state by a high caloric, high protein diet; however, he never acquired a positive nitrogenous balance. Preoperative transfusions and parenteral protein hydrolysates supplemented the oral intake.

On Sept. 15, 1948, gas, oxygen, and ether anesthesia were administered through a long endotracheal tube. The attached balloon was placed between the fistula above and the carina below. An incision was made from the level of the superior border of the thyroid cartilage to the suprasternal notch along the medial border of the left sternocleidomastoid muscle. The retropharyngeal space was exposed by retracting the sternocleidomastoid muscle and the carotid sheath structures laterally. The cervical approach was not sufficient for exposure of the fistula and the skin incision was extended downward over the mid-sternum to a level just below the third costal cartilage. The sternum was split in the midline and the anterior mediastinum was opened. The exposure was then satisfactory and the esophagus was freed below the fistula by blunt dissection. The left recurrent laryngeal nerve was observed to be incorporated in a mass of scar tissue in the region of the fistula. The cervical esophagus was developed by blunt dissection above the fistula. There was considerable scarring of the mediastinum in and about the fistulous communication of the esophagus with the trachea. The fistula was divided. The defect in the membranous portion of the trachea measured 5 cm. in its greatest diameter and it was closed with two rows of interrupted 000 silk sutures. A similar defect in the esophagus was closed in a transverse manner using two rows of 000 silk sutures (Fig. 2). The left lobe of the thyroid gland and surrounding scar tissue were sutured over the closed tracheal defect.

Postoperatively, he received 2 Gm. of streptomycin daily and 100,000 units of penicillin intramuscularly every three hours. He developed a wound infection complicated by chondritis of the first, second, and third costal cartilages on the right. On Nov. 1, 1948, the diseased cartilages were resected and the wound was packed open. The wound required secondary closure. Prior to his discharge a bronchoscopy showed no abnormality of the trachea. It

was impossible to identify the site of the healed surgically closed defect. A laryngoscopic examination showed partial return of function of the left vocal cord. Esophagogram showed no esophageal defects.

At the time of his discharge on Jan. 18, 1949, he had no cough, no difficulty in swallowing, and he had gained twenty-five pounds in weight.

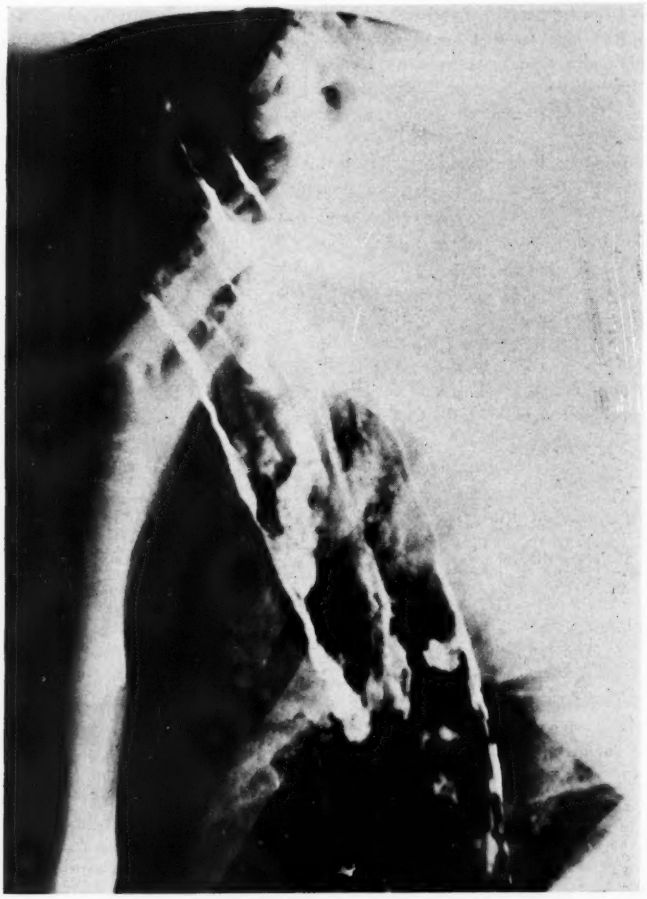

Fig. 4.—Ingestion of Lipiodol delineates the esophagotracheal fistula at the level of the superior thoracic aperture (Case 4).

Comment.—This 24-year-old white man was able to tolerate for a period of four years a fistula which had a diameter of 5 cm. No specific etiologic agent could be demonstrated but there is evidence to suggest that the fistula likely arose from a pre-existing pyogenic mediastinal abscess. The exposure of the fistula at the superior thoracic aperture required a combined cervico-mediastinal approach. Successful closure of the defects in the trachea and esophagus has led to an apparent cure.

SUMMARY

Seventy-five cases of acquired nonmalignant esophagotracheobronchial fistula have been reported in the literature during the past thirty-two years (1916 to 1949). Analysis of these cases has yielded valuable information.

The fistulas are classified on the basis of etiology. The known causes of fistula formation are infection, trauma, and esophageal diverticula. There is a definite correlation between the type of trauma and the location of the fistulous opening in the tracheobronchial tree. Traction diverticula of the esophagus show a high incidence of communication with the secondary bronchi. The most common specific infections leading to fistula formation are tuberculosis and syphilis.

Development of a communication between the respiratory system and esophagus invariably leads to characteristic symptoms. Ingestion of fluids is followed by strangling or severe paroxysms of coughing after a momentary asymptomatic pause. Diagnosis is based upon history, physical examination, roentgenographic studies, and endoscopic examinations.

Fistulas associated with active tuberculosis or syphilis should receive antibiotic therapy. Small fistulas and fistulas associated with exuberant granulation tissue should receive local cauterization and antibiotics in expectation of cure or alleviation of the local infection preparatory to later surgical treatment. Fistulas complicated by bronchiectasis or lung abscess frequently require pulmonary resection in addition to closure of the esophageal defect. Smooth epithelized communications unattended by suppurative disease of the lung are suitable for immediate and direct surgical closure.

Four patients with acquired nonmalignant esophagotracheobronchial fistula have been successfully treated by direct surgical closure. Six patients treated by this method have been reported previously in the literature during the past thirty-two years.

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SEVENTY-FIVE REPORTED CASES ESOPHAGOTRACHEOBRONCHIAL FISTULA

(1916 TO 1949)

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DISCUSSION

DR. OSLER ABBOTT, Atlanta.—I rise only to mention a factor that I think is important in the handling of these patients; I wonder if any lesion above the level of the aortic arch might possibly have an associated gastrostomy, but certainly below the level of the aortic arch I feel very strongly that if the patient needs additional nutrition he should have a jejunostomy in order to keep the esophagus at rest. Another factor is that a number of such patients may be seen within a period of eighteen to twenty-four or more hours after the acute episode of rupture joining these two organs. In that case immediate operative intervention frequently will be an unhappy factor, and we feel that in that group a particular point should be made in giving them an early jejunostomy, drainage as necessary, and keeping the esophagus at rest, usually by means of Levine suction. A large proportion of immediate traumatic esophagotracheal fistulas will clear under this type of management

alone, and we have had several experiences which have proved that point to us. One in particular was a child in whom a tracheotomy had been performed elsewhere; a large opening had been made in the posterior trachea right into the esophagus. That child was carried along satisfactorily by just utilizing the tracheotomy which was present to keep a good access for secretions, which is one of the factors in conservative management, and the child was fed by means of an indwelling Levine tube. After a period of about sixteen days the fistula was found to be satisfactorily closed. It was of quite long extent, and the child fortunately got no pulmonary complications. A similar incident was in a young Negro boy in whom there was a traumatic wound of large size in the trachea and esophagus, caused by a bullet, and the diagnosis was not made until eighteen hours after its occurrence. Operation had to be done because even two thoracotomy tubes could not control the degree of pneumothorax. Closure was performed, but in view of the amount of contamination the fistula reformed during the postoperative period and closed very rapidly under conservative management with the use of a jejunostomy. I would like to stress the use of esophageal rest, adequate attention to secretions by use of the bronchoscope or tracheotomy tube, and the use of a jejunostomy rather than gastrostomy in these lesions.

DR. JOHN S. HARTER, Louisville, Ky.—I would like to record my experience with three cases of diverticula of the esophagus occurring at about the junction of the lower third and the upper two-thirds. One of these cases was particularly interesting in that we observed the patient for seven years trying to figure out where she was bleeding from. She had frequent hemoptyses and bronchoscopy and esophagoscopy frequently were performed after these hemoptyses, and we never could ascertain where the blood came from. In one of the barium studies an esophageal diverticulum was demonstrated running to the right at about the level of the junction of the lower third and the upper two-thirds. During these seven or eight years of observation she visited various clinics around the country and no one could make a diagnosis. Finally, about 1945, she developed multiple lung abscesses of the lower lobe on the right side and that was resected, and at that time a very definite diverticulum was found extending into the substance of the right lower lobe.

Subsequently two other patients were seen at Nichols General Hospital in Louisville, who were operated on for lung abscess, and diverticula at this level were found extending into the left lower lobe. That is three cases of diverticulum extending into the lobe and because of the inflammatory changes we were never able to demonstrate what the connection was in the lung, except that the diverticulous tract simply ended in the inflammatory tissue.

DR. HERBERT D. ADAMS, Boston.—My experience with this particular lesion has been confined to those of traumatic origin, and I should like to bring up two points, one of which Dr. Abbott has already mentioned, that is, the early management of these lesions. First, it is not necessary to do an emergency procedure. If the patient is in profound shock, either mediastinal drainage or repair of the fistula at that time may be just the thing that will tip the scale and you will lose the patient. At one time, not too long ago, we felt that any rupture of the esophagus was an absolute indication for posterior mediastinotomy and drainage. However, we have proved to our satisfaction, particularly in seriously injured individuals, either with a crushing injury or a penetrating injury which produces an esophagotracheal fistula, that these patients may be in such severe shock and they may have such extreme difficulty in managing secretions, plus laryngeal edema and emphysema, that it is best to treat the shock, flood them with massive doses of antibiotics, and to do a tracheotomy if necessary to manage the secretions and laryngeal obstruction, and a gastrostomy or jejunostomy to carry on the nutrition and put the area at rest. Having done so, I believe the best approach for these lesions, certainly those below the cervical and superior thoracic strait, is through the right thorax. (Slides.)

The first slide shows a barium swallow, showing how easy it is in some larger fistulas to demonstrate the stream of barium passing from the esophagus into the trachea. The next shows a diagrammatic sketch of the approach through the right thorax. As you know, by dividing the azygos major vein, you will have full access to the esophagus and trachea, and even both the major stem bronchi, and it is possible to mobilize the fistula under direct

and excellent vision, divide the two structures, and close the openings in each with very fine sutures, with an excellent result. These patients have been managed in this manner without residual infection and without pleural contamination.

DR. CAMERON HAIGHT, Ann Arbor.—The paper by Dr. Coleman and Dr. Bunch is quite timely because of the limited recorded experience of any one person in the surgical management of acquired tracheoesophageal fistulas. I would like to refer to one type of fistula which it has been our unfortunate experience to encounter in a few cases of congenital esophageal atresia following primary anastomosis. It concerns those infants in whom there is leakage of the anastomosis with the development of a recurrent tracheoesophageal fistula. This occurs early in the postoperative course and at a time when the tissues are not in a suitable condition for surgical repair of the recurrent fistula. The surgeon is then faced with the alternative of waiting until the condition of the wound improves, or else of trying to close the fistula by chemical cauterization, as advised by Clerf for acquired esophagobronchial fistulas in adults.

If reoperation is to be done for recurrent tracheoesophageal fistulas in infants, the technical problem is a difficult and uncertain one because of the very considerable scar in the region of the recurrent fistula. Because of these difficulties and also because of the delay which is necessary before reoperation can be done, I now feel that first an attempt should be made to close a recurrent fistula by endoscopic cauterization with a bead of sodium hydroxide fused on the point of a carrier. The cauterization is done under esophagoscopic or bronchoscopic control depending upon which method gives better visualization of the fistula in the particular case. Our last patient with a recurrent fistula was treated successfully by bronchoscopic cauterization, and reoperation was therefore unnecessary.

DR. BUNCH, JR. (closing).—In regard to the remarks of Dr. Abbott, we have not found the need for gastrostomy or jejunostomy in any of our cases. We might point out that neither of these procedures answers the problem of swallowed saliva. Feedings by way of gastrostomy are unsatisfactory in cases with esophagotracheobronchial fistulas, as regurgitation of the feedings is prone to occur through the fistula and into the respiratory tract. As evidence that regurgitation occurs even into the upper esophageal region, we have recently had 3 cases of carcinoma of the cervical esophagus in which the Wookey operation was performed. In each case tube feedings introduced into the stomach escaped rather frequently from the cervical esophagostomy.

We feel that early cases of traumatic fistulas should have drainage of the mediastinum and that nutrition can usually be maintained by Levine tube and intravenous feedings.

Concerning the remarks of Dr. Adams, the posterolateral transpleural approach was used in 3 of our 4 cases, and a combined cervicomediastinal approach in the fourth. We agree with Dr. Haight that small fistulas should be treated first by local cauterization and the larger ones subjected to direct surgical closure.

The fistulas in our 4 cases were all large. In 2 the etiology was an ingested foreign body, one a small nail and the other a chicken bone. The third case was probably tuberculous in origin as the left upper lobe of the lung was studded with small calcified nodules and many calcified tracheobronchial lymph glands were present. The etiology of our fourth case could not be determined.

THE COMBINED ABDOMINAL AND RIGHT THORACIC APPROACH TO LESIONS OF THE MIDDLE AND UPPER THIRDS OF THE ESOPHAGUS

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PITTSBURGH, PA.

IN RECENT years there has been a pronounced increase in attention to both benign and malignant obstructing lesions of the esophagus. This has been due, in large part, to the work of Phemister, Sweet,[1] Garlock,[2] and others, whose techniques are familiar to all of you. In essence, these principles have meant the adoption of a direct attack upon the problem by the use of esophagectomy and esophagogastrostomy and the abandonment of the indirect approach as demonstrated by the Torek type of operation. These workers have each employed the left transthoracic, transdiaphragmatic approach for lesions at all levels of the esophagus and for those at the cardiac end of the stomach.

In 1946, Ivor Lewis[3] published the first account of his two-stage combined abdominal and right thoracic approach for carcinoma of the middle third of the esophagus. At the first stage the abdomen is carefully explored through an upper left paramedian incision. If there are no metastases, the greater curvature of the stomach is freed in its upper half. The vasa brevia, the left gastroepiploic artery, and the omentum are divided well away from the stomach, leaving a vascular arch attached to the greater curvature. The gastrohepatic omentum is then divided well away from the lesser curvature, and the left gastric artery is tied and divided near its origin (Fig. 1). Lewis recommended fine silk throughout for ligatures and emphasized the need for meticulous hemostasis in order to reduce inflammatory changes and the resulting adhesions. This stage is completed by the construction of a Witzel jejunostomy. For a period ranging between seven and fifteen days after the first stage every effort is made to improve the patient's nutrition, and it was the experience of Lewis that the jejunostomy made this possible.

The second stage is performed through the right thorax by removal of the sixth rib and an incision in its bed. If the lesion is found to be resectable, the vena azygos major is divided between ligatures, the involved segment of the gullet is dissected free, the lower esophagus is mobilized, and the portion in the hiatus is freed by digital dissection. The cardia is then drawn up through the hiatus and the peritoneum is divided circumferentially. Adhesions which have formed are gradually liberated as the fundus and body of the stomach are drawn up through the hiatus. When the organ has been sufficiently mobilized to permit placing the fundus well above the level of the cancer, the esophagus is severed at the cardia and the opening in the stomach is closed. The upper end of the stomach is made secure to the mediastinum and chest wall; the esophagus is placed upon the stomach and an end-to-side anastomosis is performed well

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above the carcinoma, the esophagus being divided after the first posterior layer of sutures has been completed (Fig. 2). A catheter is placed at the anastomosis line and brought out through an intercostal stabwound to be attached to a water-seal drain. Lewis predicted that both stages could be done at the same time in patients who are exceptional risks for surgery.

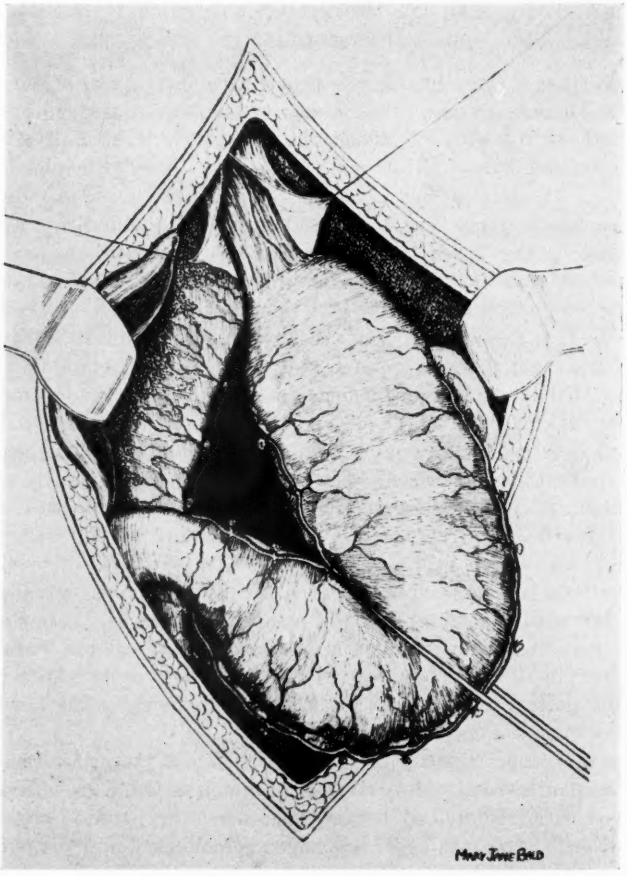

Fig. 1.—Mobilization of the stomach by laparotomy (first stage).

The advantages of the abdominal approach were enumerated by Lewis as follows:

1. A far more satisfactory exploration of the abdomen can be made.
2. A jejunostomy can be performed and is of great value in improving nutrition and hydration between stages and maintaining alimentation in the immediate postoperative period following completion of the second stage.

The advantages of the right transpleural approach are:

1. Far better access to the upper two-thirds of the thoracic esophagus.
2. Only the azygos vein has to be divided to lay bare the entire esophagus.
3. The aortic arch, instead of an obstacle, becomes a safety barrier between the surgeon and the other pleural cavity. Instead of separating the

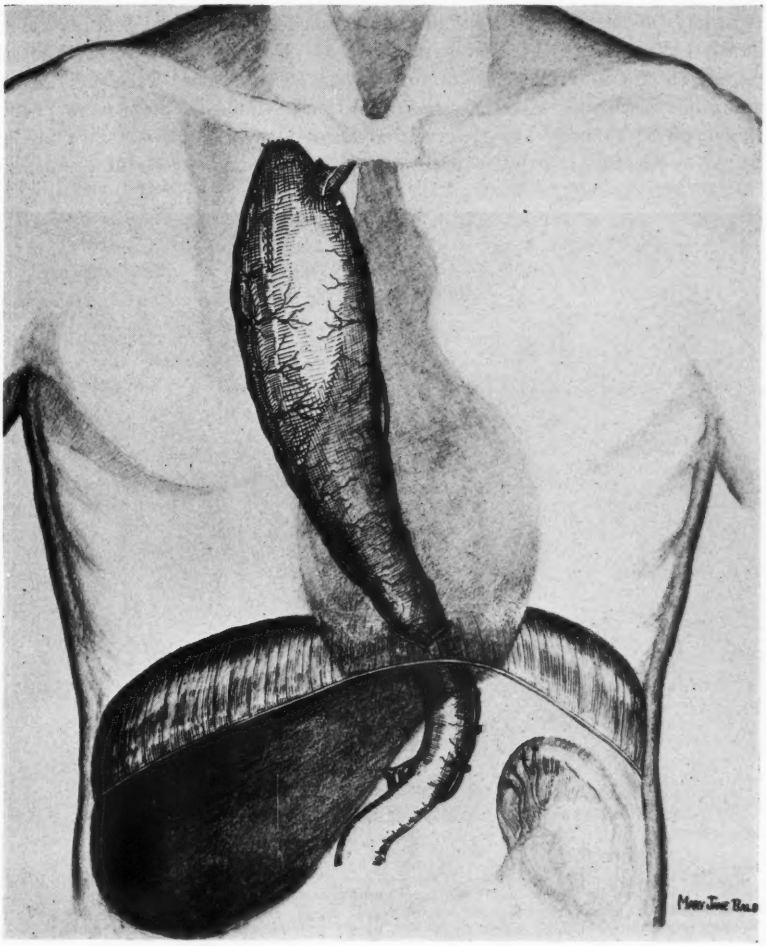

Fig. 2.—Semidiagrammatic illustration of the end result after the right thoracic approach to the esophagus (second stage).

esophagus or its neoplasm bluntly and blindly from behind the arch, it can be dissected under full vision.

In 1948, Macmanus[4] reported the application of the combined abdominal and right thoracic approach of Lewis in two patients and advocated its use for

lesions of the lower third as well as for the middle third of the esophagus. The only addition to the technique of Lewis was division of the right crus of the diaphragm at the time the abdominal stage was done.

In August, 1947, we elected to follow the technique of Lewis in the management of an extensive lye stricture which necessitated anastomosis of the stomach to the upper third of the esophagus. The patient had been fed by gastrostomy for twenty-five years and the esophageal lumen had been completely obliterated for many of these years (Fig. 3). Although the result has been extremely satisfactory (Fig. 4), it must be stated that there were difficulties of considerable magnitude along the way. However, none of these were peculiar to this type of surgery but represented hazards which the operator must be prepared to encounter in performing any major surgical procedure. As things

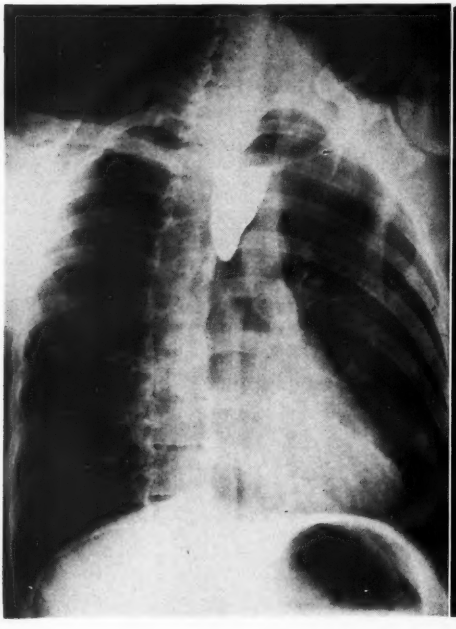

Fig. 3.

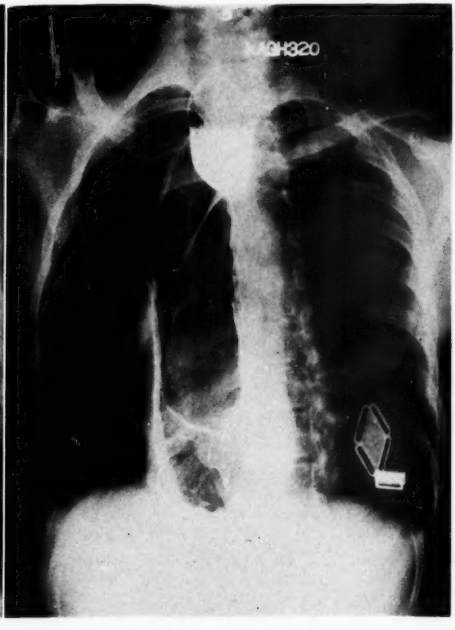

Fig. 4.

Fig. 3.—Lye stricture of the esophagus showing dilated lumen above upper limit of the stricture. There was no other lumen in the esophagus except in the lower 8 cm.

Fig. 4.—Roentgenogram showing end result after resection of the esophagus and a right-sided anastomosis of the stomach to the upper esophageal stump.

stand now, this patient is able to eat any foods by mouth although the anastomosis stoma is small and we would like to enlarge it. We have been trying to design a crushing clamp which might be placed on the circumference of the anastomosis in such a fashion as to enlarge the orifice without requiring a thoracotomy. In an instance such as this, the gastrostomy must be closed and this was done at the first or abdominal stage.

Since this first success, the Lewis operation has been planned in the surgical treatment of seventeen patients having carcinoma of the middle or upper third of the esophagus. The results are summarized in table form (Table I). As can be seen, all patients were male, only two were less than 60 years of age, all had experienced symptoms for several weeks or longer, and every one had reached the stage of obstruction at which only water would pass, and this with difficulty in some. Only two patients in the group were considered to be good surgical risks. There were five surgical deaths, three after the abdominal stage and two after the thoracic stage. All five deaths occurred within the first twenty-four hours after operation. Four patients received the first stage operation but could not be prepared successfully to withstand the thoracic stage and all four were subsequently released from the hospital. Four patients were found to be not resectable at the thoracic stage, three because of the extent of the disease and one because of cardiac disorders which precluded resection of an operable carcinoma at the level of the azygos vein. All patients in this series had experienced weight loss varying between sixteen and seventy pounds. Several of these patients were found to have metastases in the left gastric nodes at the time of the abdominal stage, but in no such instance was the definitive plan interrupted because of this finding alone. Twelve patients had lesions of the middle third of the esophagus (Fig. 5) while only five were found present in the lower portion of the upper third (Fig. 6). In these latter patients, anastomosis to the upper third of the esophagus was necessary in order that it might be transected well above the lesion.

TABLE I. TABULATION OF FACTORS IN SEVENTEEN PATIENTS HAVING CARCINOMA IN THE MIDDLE AND UPPER THIRDS OF THE ESOPHAGUS

CASE NUMBER	SEX	AGE (YR.)	DURATION OF SYMPTOMS (MO.)	LEVEL OF LESION	RESULT
1	M	52	5	Middle	Successful
2	M	56	4½	Upper	Death after first stage
3	M	66	3	Middle	Successful
4	M	71	4	Middle	Inoperable at second stage
5	M	61	2	Middle	Death after first stage
6	M	68	3	Upper	Death after second stage
7	M	60	2	Middle	Successful
8	M	65	4½	Upper	Inoperable at second stage
9	M	69	2	Middle	Death after first stage
10	M	71	3½	Middle	Inoperable at second stage
11	M	62	4½	Middle	Death after second stage
12	M	67	2	Upper	Successful
13	M	60	1½	Middle	Second stage not undertaken
14	M	69	3½	Middle	Second stage not undertaken
15	M	64	2½	Middle	Second stage not undertaken
16	M	63	5	Upper	Second stage not undertaken
17	M	61	2½	Middle	Inoperable at second stage

It is obvious that in this group of seventeen individuals having esophageal carcinoma the indications for surgery have been extended well beyond the scope of conservatism. This is not typical of the general philosophy of either author for the treatment of carcinoma in most situations. However, we agree with many contributors to the literature on this subject that a rather radical view-

point is thoroughly warranted. In some instances palliation alone was sought for. Success in this brings rewards of very appreciable magnitude to the patient. On other occasions poor-risk patients have been accepted for surgery in the belief that death from untreated carcinoma of the esophagus, with or without gastrostomy, is a terrible ordeal for both the victim and his family.

As our experience has increased in the management of such cases, it has been our tendency to omit the jejunostomy originally advised by Lewis. This has been based upon our inability to produce good results in improving nutrition thereby. We have also tried to reduce the interval between stages as much as possible, in one instance to twenty-four hours, but in general to a period of from three to seven days, depending, of course, upon the condition of the patient. We

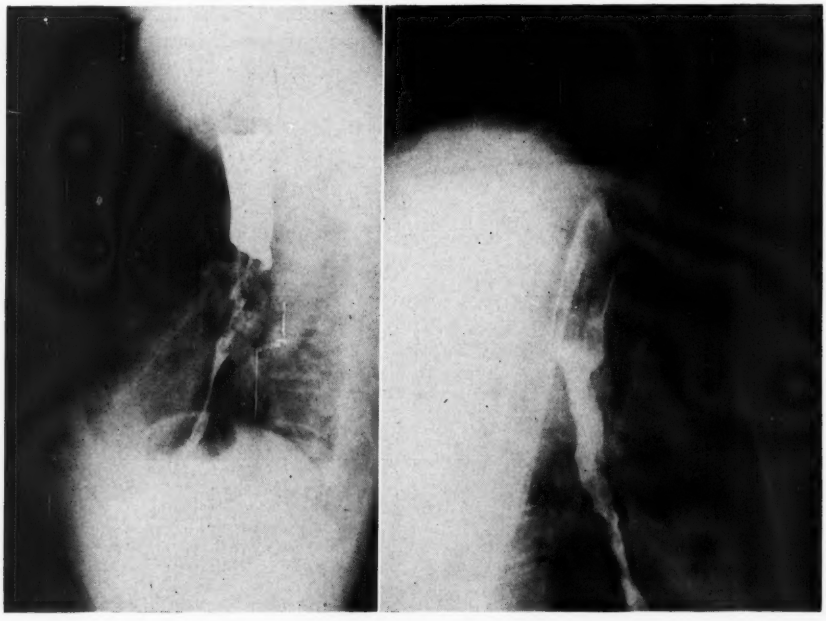

Fig. 5. Fig. 6.

Fig. 5.—Roentgenogram demonstrating typical appearance of carcinoma at middle third of esophagus.

Fig. 6.—Roentgenogram showing carcinoma in lower portion of upper third of esophagus.

agree with both Lewis and Macmanus that it would be preferable to accomplish both stages at one operation, but in no instance to date has this been feasible. There are two principal reasons for our efforts to reduce the interval to a minimum. First, the longer the second stage is put off, the more adherent the stomach becomes within the abdomen; and second, our inability to accomplish good results with the use of a jejunostomy has been coupled with the observation that the condition of the patient sometimes tends to deteriorate during the interval.

Fig. 7.

Fig. 8.

Fig. 7.—Roentgenograms (anteroposterior and lateral) showing carcinoma in the middle third of esophagus. This patient had a posterior gastrojejunostomy which was taken down at the first stage.

Fig. 8.—Anteroposterior and lateral roentgenograms showing a short esophagus, a hiatus hernia, and obstruction at the level of the bifurcation of the trachea. This proved to be adenocarcinoma arising at the cardia of the stomach which was situated in the midthorax.

Two of the patients in this series presented unusual conditions. The first of these, a male patient 52 years of age who had had symptoms for five months, presented an epidermoid carcinoma of the middle third of the esophagus (Fig. 7). The unusual feature in this instance was a high, short loop, posterior gastrojejunostomy which had been performed fourteen years previously for duodenal ulcer. It was necessary to take down this gastrojejunostomy during the abdominal stage.

The second patient presenting an unusual feature was a man 61 years of age. He had experienced dysphagia for two months but had been losing weight for eight months. There was, in addition, pronounced hypertension with impaired cardiac function. An esophagram revealed an obstructing lesion of the middle third of the esophagus at the level of the bifurcation of the trachea with a hiatus hernia (Fig. 8). Esophagoscopy showed the lesion to be well up in the middle third of the esophagus and bronchoscopy demonstrated no evidence of invasion at the carina. The biopsy which was taken at the time of esophagoscopy revealed adenocarcinoma and normal gastric mucosa. We could not understand these observations in tissue obtained at the level of the sixth dorsal vertebra and repeated both the radiographic studies and esophagoscopy with identical results. This is the only patient in the entire group who was found to have adenocarcinoma. The explanation was not revealed until laparotomy was performed and the first stage had been undertaken. A large hiatus was present which would admit the hand, and the cardiac end of the stomach was high in the mediastinum, rather tubular in shape, and conical at the cardia. The esophagus was obviously very short and the cardia lay in the midthorax. The left gastric artery disappeared into the hiatus hernia for some distance before reaching the stomach. The carcinoma had arisen at the cardia and was gastric in origin. Unfortunately, this was one of the patients who did not survive the first stage and again unfortunately, autopsy was refused and this unusual specimen was lost.

We agree that Lewis has made a strong case for his operation and we have found his contentions to have been correct save for our failure to achieve favorable results from jejunostomy. There is no question whatever that access to the esophagus is much better on the right side and that the organ can be mobilized in its entirety with much greater ease than on the left. The abdominal stage has, however, been rather more tedious for us than Lewis has indicated it to be. We have found it quite difficult to mobilize the upper end of the stomach and the lower esophagus in most instances. This part of the operation has been found to be of considerable magnitude as has been shown by the deaths which have occurred thereafter and by our inability to complete both stages at the same time thus far. To our minds, the question rests upon the results of balancing these difficulties against the great advantages of easy accessibility to the esophagus on the right side. We have found the latter to outweigh the former. We are not prepared, however, to agree with Macmanus that this procedure should replace the left thoracic approach for lesions in the lower third of the esophagus.

SUMMARY

Experiences in the surgical management of one patient having a lye stricture of the esophagus and seventeen patients presenting carcinoma of the middle or upper thirds of the same structure have been reported. The combined abdominal and right thoracic approach devised by Ivor Lewis has been employed in each instance. Except for the value of jejunostomy, the advantages of this method, cited by Lewis, have been borne out in our own experience. Since successful surgical attack upon such lesions of the esophagus is of recent origin, the methods available to us have not been explored fully as yet. This technique, in our opinion, warrants widespread application so that its place in our armamentarium may be ascertained.

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DISCUSSION

DR. RICHARD SWEET, Boston.—I believe that Dr. Kent's experience presents a very ample demonstration of my opinion that this operation has almost no merit whatsoever. I have long been of the opinion that it would present troublesome difficulties as he has shown and described in his 17 cases. It is almost trite to say that the most obvious objection to it is that, once having put the patient through an extensive abdominal operation for the mobilization of the entire stomach, the surgeon then subjects the patient to another serious operation and finds, as he did in several of his patients, that the disease is hopeless and that the patient must therefore be condemned to go without relief.

He has himself discovered what I learned long ago, that a jejunostomy is of no use or may even present certain objections in the management of these patients. Any patient who is so ill that he appears to require a jejunostomy should not be operated upon. Furthermore, the contention of Mr. Ivor Lewis that the abdominal dissection can be better done through an abdominal incision is wrong. It can be done much more easily and more thoroughly through a thoracic or, as Dr. Garlock has done, through an abdominothoracic incision.

It seems to me that Dr. Kent's mortality is too high, but that may be, as he says, because he has chosen to operate on very advanced cases, and he has a small series. Of course, any small series is apt to be weighted accidentally by unfortunate occurrences. I do not know what his resectability is going to turn out to be when he has done 100 or more of these cases. I might say as a matter of interest that working through the left side (and I realize that it is more difficult technically—still a surgeon must overcome certain technical difficulties—) in my experience at the Massachusetts General Hospital, operating on every patient who was considered to be well enough, it has been possible to resect the tumor in mid-esophageal patients in 72 per cent of cases explored.

If I were to do this combined operation I would do it in one stage; turning the patient over and performing the thoracic portion immediately. As Dr. Kent has learned, interrupting an operation of this sort for a period of days increases the difficulties.

If Dr. Kent or Mr. Lewis can show two things, I will be willing to change my opinion; one is, that his operative mortality is lower than mine; and the other is, that the long time survival of the patients is greater. Until then I shall do it my way.

DR. JOHN H. GARLOCK, New York.—I feel exactly as Dr. Sweet does, although I do not think I could put it as succintly as he did. While I was in London in 1947, I talked to Mr. Lewis about this operation and he indicated that the great difficulty in this right-sided approach with the preliminary abdominal exploration and mobilization of the stomach, resulted frequently in the finding at the second stage of a hopelessly inoperable lesion which could not even be given the benefit of palliative resection. My main objections are two; the first I have already indicated; the second is that you face the patient with a real operative risk in the mobilization operation done at the first stage. Instead of accomplishing the operation in one stage, you give the patient two risks of major proportions.

DR. JOHN POOL, New York.—I would like to report an experience of six cases in which this procedure was done, in four of whom the lesion was resectable and in two of whom, where the lesion was not resectable, a by-pass procedure was carried out so that the patient was left with a continuity of digestive tract, and the operation was not, therefore, without benefit to the patient. (Slides.)

I have here, just for comparison, two patients in whom the left approach for the lower quarter of the esophagus, approach through the left side of the thorax, did not allow resection of the esophageal carcinoma, but by simple mobilization of the fundus of the stomach through the diaphragm a by-pass anastomosis could be effected at this point and continuity restored. You can see some reflux of barium in the distal esophagus at this point. Here also is another demonstration of such a by-pass, with again reflux of barium in the inferior portion of the esophagus. I do not believe that this procedure has materially prolonged life in these patients; they both survived approximately six months, but during that time they were able to swallow and there was not recurrence to the point of blockage of the carcinoma at the level of the anastomosis although it was quite close to the upper limit of the disease. This slide will show you a very extensive carcinoma in which the Ivor Lewis procedure was carried out. It was not possible on exploring the chest to mobilize the carcinoma, but the stomach could be brought up and an anastomosis performed above the level of the carcinoma. This was done in one stage.

DR. J. R. PAINE, Buffalo.—I am sorry my colleague Dr. Macmanus is not here to discuss this paper. I also hope that Dr. Sweet and I do not cease to be friends. I also hope that he has tried a right side approach when he speaks as he has. I had the same impression Dr. Sweet had, largely because I followed his writings on the subject, until I tried it. Dr. McManus convinced me that it was a worth-while procedure. We have pooled our efforts, and I would like to show you our results.

We have operated upon 60 patients with carcinoma of the esophagus. We have been able to resect 33. There have been 7 deaths in the total number. We have used the left abdominal right thoracic approach in 27 patients, and of the 27 we have been able to resect in 17. Only 2 of the 27 have been done in two stages; 25 have been done at one stage. That makes a rather long operation but the patients have stood it, I think, as well as they would any type of operation. There are very difinite disadvantages and very definite advantages to this operation. The two major disadvantages have already been mentioned. A major surgical procedure is performed before resectability is determined, but we sometimes do major surgical procedures before we determine the resectability of many tumors. An adequate closure of the hiatus about the stomach is very difficult; I doubt if that is a disadvantage. In the majority of our cases we have made no attempt to suture the hiatus to the pyloric portion of the stomach after it has been brought into the right chest.

There are definite advantages, too; a very adequate amount of proximal esophagus may be removed without increasing the difficulty or mortality of the operation. Both phrenic nerves and diaphragm remain intact, and that, we think, is a very important point. The respiratory mechanism is left as complete as possible after operation. The thorax is opened for a shorter time, thus disturbing the cardiorespiratory mechanics for a much shorter period than when using the left approach. The incidence, in our experience at least, of postoperative atelectasis and pneumonitis has been less. Interference by the aortic arch is less. In only 3 instances have we had any trouble with cardiac irregularity. And last, but far

from least, for a right-handed operator, to anastomose the stomach to a short esophagus in the right chest is much easier than in the left chest. I think Dr. Sweet himself has said that the technical difficulty of making an extremely high anastomosis in the left chest is very great. You will not find that to be true in the right chest.

DR. JOHN H. GIBBON, Jr., Philadelphia.—I have been much interested in this discussion and I must say I agree completely with Dr. Sweet and Dr. Garlock. I take it that one of the reasons for proposing this operation is the difficulty of making an anastomosis high in the chest, that is, a supra-aortic anastomosis on the left side. The mortality in that group is certainly higher than with lesions that lie below the arch, where the anastomosis can be made very easily on the left side. Dr. Sweet and Dr. Garlock have both reported cervical esophagogastrostomies; Dr. Garlock's patients unfortunately died early, but Dr. Sweet's patient lived. Dr. Lyman Brewer of Los Angeles has recently reported such a case, and so has Dr. Wylie of New York. Dr. Frank Allbritten and myself have recently had 3 cases of cervical esophagogastrostomy. One of these patients died, the other 2 are living and well at present.

The anastomosis is much easier in the neck than it is high in the chest. One of our successful cases was a complete esophagectomy. The man is still living five months later, in good health except that he has a carcinoma of the rectum which he refuses to have operated upon. It was a total esophagectomy, anastomosing the stomach to the pharynx. I think the feasibility of these cervical anastomoses for lesions in the upper third of the esophagus does away with the arguments advanced for the approach from the right side of the chest.

DR. J. M. CHAMBERLAIN, New York.—It takes a brave man to stand up at this time and defend Dr. Kent, especially after Dr. Garlock and Dr. Sweet's opening discussion. I imagine that it is because of my comparatively small experience that I have the courage to do so. I just want to mention two small points. I should like to emphasize the importance of preserving the intact diaphragm to which Dr. Paine has already referred. Many of these patients, as you all know, have a very low respiratory reserve, either because of emphysema or later because of some postoperative complication, and a good technical result may be a clinical failure simply because of respiratory insufficiency. Bronchial peristalsis and the cough mechanism are Nature's protection against these postoperative complications, and the diaphragm of course is extremely important in both. If the diaphragm is crippled by Dr. Sweet's operation, it is conceivable that some of these patients are lost simply because of pulmonary complications, as has happened in one of our cases. We have used fluoroscopy on many of our patients on the first postoperative day, and the lateral half of the diaphragm does not move and the medial half moves but slightly, so there is no doubt that the diaphragm is crippled as the result of the thoracoabdominal approach.

My second point is in defense of the right-sided approach and has to do with the resectability of the high lesion. For a long time I avoided the right-sided approach because I disliked putting the patient through a major abdominal stage only to find, upon opening the chest, that the tumor could not be resected. It is a matter of mental gymnastics, actually, to change a whole philosophy and assume that they are all operable or the obstruction can be shunted. Dr. Pool got around this by anastomosing the stomach above the lesion regardless of whether or not the tumor is removable. So in our last several cases we have assumed that all cases are resectable, not 33 out of 60, which is about 50 per cent, and not 72 out of 100—but all are resectable in the sense that if the stomach can be mobilized an anastomosis may be accomplished above the lesion. As much of the lesion as possible is then removed. We do both stages immediately. The stomach is brought up through the hiatus, without opening the crux; and the "shunt" is done regardless of whether all the cancer is removed or not. The older surgeons here probably have nothing but contempt for the gastrostomy procedure but the shunting operation, at least in our small experience, has led us to believe that the patient lives three to six months more happily than he would with a gastrostomy.

DR. JULIAN JOHNSON, Philadelphia.—If one desires to perform an esophageal resection from the right-sided approach, from choice or necessity, there would seem to be little point in doing it in two stages. We open the right chest first to demonstrate that the lesion is resectable. The patient may then be turned back slightly and a left subcostal incision made to partially free the stomach from its vascular attachments. An assistant working on the abdomen may then pass the stomach up to the operator working on the thorax. This plan has worked out quite satisfactorily for us and has the advantage of determining operability early.

DR. CHARLES P. BAILEY, Wyncote, Pa.—We have usually employed the left-sided approach for esophageal resection at all levels, but recently, following experimental work by Dr. Victor Satinsky, who is associated with us, we have attempted a one-stage, right-sided thoracoabdominal approach for high esophageal lesions.

In addition to wide severance of the diaphragm, and mobilization of the esophagus and stomach from the right side, our technique includes division of the esophagus at the gastroesophageal juncture, closure of the esophageal hiatus, and introduction of the stomach into the chest through a new hiatus in the right posterior diaphragm. Since the stomach now ascends into the thorax in a straight line, directly from the pylorus, greater length is afforded for high anastomosis.

This approach was very effective in dogs, but unfortunately did not end happily in 2 cases tried so far. The first was a poor risk patient who had a huge tumor occupying about two-thirds of the esophagus, and at the time of operation it was adherent to the arch of the aorta in such a way that I believe it could not have been removed had we gone in on the left side. I must admit that after it was over I wondered whether it would not be a good idea to go in on the left side in such a case because then you would not be tempted to take it out. However, we did succeed in extirpating the tumor and establishing an esophagogastrostomy with ease. The patient did well for twenty-four hours, then suddenly died, apparently of a cardiac complication; he was a very seriously ill man and had had an obstruction for some weeks prior to surgery.

The second case was a man in rather good condition who had a high esophageal lesion. Anastomosis was established by means of our one-stage, right-sided thoracoabdominal approach, and the patient was in good condition at the end of the procedure. The next day, however, he turned quite yellow and showed all the signs of uncontrollable hemolytic blood transfusion reaction, and died after six days from that cause. At autopsy we found an excellent primary healing of the anastomosis, and everything about the operation seemed to be good.

I thought it best to report these 2 cases because no one seems to have performed quite such a procedure. I hope we will have better success with our approach in the future. Meanwhile, a detailed account of the technique is being prepared for publication.

DR. EARLE B. KAY, Cleveland.—To solve the problem of high esophagogastric anastomosis, I spent some time in the experimental laboratory in 1941, in an attempt to find a technique applicable to high esophagogastric anastomosis.

The first method employed was the use of reversed gastric tubes. The operation was divided into two stages. The first stage consisted of fashioning a reversed Beck-Jianu gastric tube through an abdominal incision. The second stage performed seven to fourteen days later consisted of resecting the esophagus. The previously prepared gastric tube was then brought through the diaphragm for the anastomosis.

The second stage was always very difficult because of the development of adhesions about the previously mobilized stomach and gastric tube. In one patient upon whom this procedure was attempted, adhesions prevented adequate mobilization of the gastric tube. The increased technical difficulty caused by adhesions is a very definite criticism of any two-staged procedure as described in this paper.

To obviate this difficulty the operation was then changed so that the gastric tube was inserted through the diaphragm into a pneumothroax space within the chest. The gastric

tube was then readily available in the pneumothorax space at the second stage and made the technique simplified. This might be helpful if a two-stage, right-sided approach as reported is to be employed.

However, as the various advances in esophageal surgery developed it was found that high anastomoses could be accomplished without the use of reversed gastric tubes. The first total thoracic esophagectomies and esophagogastric anastomoses performed by me were also accomplished by utilizing two incisions, first an abdominal one and then a thoracic one, done in one stage. The use of two incisions was also found to be time consuming and unnecessary. Adequate exposure for both the thoracic and abdominal aspects of the operation can be obtained through the thoracic incision. The exposure is through the bed of the sixth rib. Occasionally additional exposure for the abdominal aspect is obtained by resecting the seventh rib anteriorly and moving the self-retaining retractor forward. It is also possible to resect the fifth rib posteriorly to allow better exposure for the anastomosis.

Thirteen total thoracic esophagectomies and anastomoses performed at the apex of the chest as well as one performed at the level of the pharynx have been accomplished in this manner with what was felt to be adequate exposure.

DR. W. EMORY BURNETT, Philadelphia.—I should like to bring to your attention something which I am sure many of you have tried in the exposure of the high anastomosis on the left. After doing the mobilization through the seventh, eighth, or nineth ribs as usual, then finding it difficult to reach the high level, we have, on two occasions made another incision through the resected third rib bed and found it made the anastomosis considerably easier; it apparently did not increase the risk although it might be preferable to have a fairly good risk patient for extending the operation in that way. However, it shortens the time of anastomosis and this compensates for the extra incision.

DR. HARBISON.—It is presumptuous to make any further comment on this subject. I realize it is highly controversial and difficult to evaluate. I feel very strongly that Dr. Sweet should try some of these because I would like to see what his technical skill would accomplish in that operation and to have some comments from that side. Certainly the only real advantages that I can see are the better resectability of the lesion from the right with the aortic arch out of the way, better resectability from the viewpoint of cancer surgery. The one-stage operation is obviously the best, and we have attempted it, but it has been a question of poor-risk patients who were not able to stand it.

DR. KENT.—There is no reason for me to speak except that I must acknowledge and share with Dr. Harbison the criticism which has been directed at this presentation. We are fully aware that the results shown here today provide excellent ammunition for critical attack, nevertheless we persist in our opinion that these results are due primarily to the poor selection of patients for surgery, or rather, to the acceptance of poor-risk patients for operation.

We expected sharp criticism, we welcomed it, and we would have been disappointed had it not been forthcoming. We believe that in recent years the meetings of this Association have changed in many respects and that one of the more serious differences has been the consistantly agreeable character of our discussion from the floor. We are happy to have been responsible for a revival of such spirited discussion.

FURTHER OBSERVATIONS ON PACKING OF MEDIASTINUM FOR ESOPHAGEAL VARICES

JOHN H. GARLOCK, M.D., AND (BY INVITATION) MAX L. SOM, M.D.
NEW YORK, N. Y.

IN NOVEMBER, 1947, we reported our experience with two cases of severe bleeding due to varices of the esophagus treated by gauze packing of the upper thoracic mediastinum. The purpose of this procedure was the formation of granulation tissue in the mediastinum surrounding the upper thoracic esophagus in the hope that there would develop in this tissue an extensive periesophageal venous plexus capable of taking the load from and reducing the pressure in the varices themselves, thus shunting more blood from the portal to the caval circulation. Experiences with six additional patients, eight in all, form the basis of this report.

It is important to stress the pathologic anatomy of the venous blockade in portal hypertension, especially in the light of the observations made by Baronofsky in a recent article published in Surgery. It seems to us that the most important area of contention centers about the cardiac end of the stomach and lower esophagus. It is well known that, except in rare instances, the lower esophageal veins drain into the caval system and the veins in the upper stomach empty into the portal system, mainly through the left gastric vein. That there also exists a fine anastomotic connection between the lower esophageal and cardial veins, thus uniting the portal and caval circulations at this point, there can be no doubt. The injection studies of Kegaries, in 1934, definitely established this. These anastomotic channels lie in both the submucosal and submuscular areas, as do also the regularly demonstrated veins in the lower esophagus and upper stomach.

It is also well known that not every case of portal hypertension, whether of intrahepatic or extrahepatic origin, is complicated by bleeding from esophageal varices. It seems clear to us, therefore, that the reason for this is to be found in the extent and degree of the anastomotic network between the caval and portal systems at the cardial and lower esophageal areas. With a poorly developed communicating network, the chances for compensatory dilatation of the lower esophageal veins would be greatly minimized. In the presence of a rich anastomosis, the increasing pressure in the portal system would be transmitted more easily through these communicating channels into the esophageal venous system, thus causing the formation of submucosal varices. In the presence of a poorly developed communicating system, the compensatory mechanism in this area takes other directions, mainly through the azygos and diaphragmatic veins. However, it is well known that these latter communications may also be poorly developed.

From the Surgical Service and the Laryngological Service of Dr. Rudolph Kramer, Mt. Sinai Hospital.

Read at the Twenty-ninth Annual Meeting of The American Association for Thoracic Surgery, New Orleans, La., March 29-31, 1949.

Kegaries' observations may very well be repeated at this time: "It is probable that the capillary-like anastomosis at the cardia offers a marked resistance to the flow of blood from the portal to the systemic veins as in the case when the portal circulation becomes obstructed. In such instances the increase of venous pressure must exert itself upon the veins below the cardia for some time before the resistance of the cardia is overcome. Varices result from an increased flow of blood through a vein and an inability of the muscular and elastic fibers to withstand an increased intravenous pressure at the cardia; and as has been noted previously, the submucous veins of the esophagus are well supported and it is reasonable to believe that the formation of varices first occurs below the cardia and secondly above that point after collateral channels of the anastomosis have been established. *Where several veins of large caliber cross the cardia, the formation of varices above the cardia is probably more rapid. When present they are no doubt the first veins in the region of the cardia to become enlarged.*"

There is no need in this paper to enter into any extended discussion concerning the causative factors in the production of portal hypertension. Whether the cause is intrahepatic (cirrhosis of the liver) or extrahepatic (thromboses of the spenic and/or portal veins, cavernomatous transformation of the portal vein, external portal vein compression, etc.) the effect is the same and is measured in terms of a markedly increased pressure within the portal venous system. The finding of venous dilatations, whether they be located at the cardia and lower esophagus, in the hemorrhoidal area, along the falciform ligament of the liver or the retroperitoneal area, is evidence of an attempt at establishing a compensatory mechanism, the main purpose of which is to reduce the pressure in the greater splanchnic area and portal bed by shunting blood into the caval system. All observers of the general symptom-complex of portal hypertension are agreed that the most alarming symptom, one prone to cause death of the patient quickly, is bleeding from esophageal varices. Therefore, all therapeutic efforts have been directed towards eliminating or greatly minimizing this all too frequently fatal complication.

Since 1894, when Banti first suggested splenectomy, many remedies have been suggested and tried. These included: (1) omentopexy; (2) portocaval anastomosis, first successfully consummated by Vidal in 1903; (3) various vein anastomoses; (4) ligation of various gastric vessels; (5) injection of sclerosing solutions into esophageal varices, first performed by Crafoord and later popularized by Moersch; (6) suture and nonsuture anastomoses between portal vein and inferior vena cava and splenic to renal veins; (7) extensive gastric resection (Wangensteen); and (8) total gastrectomy (Phemister and Humphreys).

Most of these measures have long since been abandoned because they were found to be ineffectual in controlling the bleeding. The portocaval shunt operation and the splenorenal vein anastomosis, advocated by Blakemore and Whipple, have more physiologic basis than any procedure heretofore suggested. Yet, even these more logical operations are time consuming and carry with them

a high operative mortality. It is possible that further experience will indicate more clearly which patients should or should not be accorded these operations and that eventually the operative mortality will fall to a more reasonable level.

The observations of Wangensteen and Baronofsky are provocative and open to considerable discussion. On their assumption that it is unreasonable to believe that mere hydrostatic distension of the esophageal varices and their eventual rupture is the sole cause of the hematemesis, they advance the theory that, because of impairment of nutrition of the mucous membrane overlying the varices due to venous pooling, these tissues present a lowered resistance to the action of gastric digestive juices. The initial factor, therefore, becomes a chemical destruction of the impaired mucous membrane, followed subsequently by rupture of the unprotected varices. They, therefore, recommend almost total gastrectomy for three reasons: (1) to remove the acid peptic factor; (2) if there is a communication between the portal and caval systems at the cardia, then gastrectomy should isolate the esophagus from the portal system; (3) gastrectomy reduces the blood inflow into the portal circulation.

There comes to mind immediately a number of sound reasons why this theory is untenable. In the first place, on the basis of innumerable direct observations of the esophagus through the esophagoscope, one of us (M. L. S.) has never seen mucous membrane erosions in this disease which could be interpreted as being caused by regurgitation of gastric juice. The latter has been observed frequently in peptic esophagitis and benign peptic ulcer of the lower esophagus. Second, those of us who have had any considerable experience with surgery of the esophagus are well acquainted with the frequent extreme friability and remarkable thinness of the mucous membrane of this organ. It is not difficult to imagine a markedly distended vein beneath such mucous membrane giving way under the repeated trauma of swallowing large or hard boluses of food. This we believe to be the logical mechanism of the bleeding in this condition. Third, it is difficult for us to understand why a high gastric resection or a total gastrectomy should separate the portal from the caval circulations. The jejunum, which is utilized in effecting these anastomoses, is as much a part of the portal backflow as is the stomach. There is every reason to suppose, therefore, that following the gastrectomy, anastomoses will be effected between the jejunum and the upper stomach or esophagus, thus reestablishing the connection between the portal and caval systems. Inasmuch as most of the esophageal veins are located in the submucosal area, the back pressure will be felt again in the varices and hematemesis should recur.

Of the eight patients reported by Baronofsky from Wangensteen's Clinic, four died postoperatively. The case descriptions indicate that the latter were very poor operative risks. Of the four survivors, one died nine months after a 90 per cent gastric resection following a severe hematemesis. The second patient, a boy 3 years of age, had one bleeding episode two years and five months after a 98 per cent gastric resection. The third has had no further bleeding for two years following a 95 per cent resection. The fourth patient had a total gastrectomy and has remained symptom free for seven months.

We have approached the problem of bleeding from esophageal varices in a more direct way in that advantage is taken of the communicating system at the cardia between the portal and caval circulations by attempting to reroute the portal blood from the vulnerable submucosal varices to a surgically produced new periesophageal venous plexus. The beneficial effect in the first case was obtained quite by accident. This patient sustained a perforation of the cervical esophagus during esophagoscopy for varices following a severe hepatitis a year before. The infection of the posterosuperior mediastinum was drained by another surgeon at the hospital through a cervical incision and packing was inserted. The subsequent complete abatement of hematemesis in this patient led to the use of this procedure as a definitive measure in the treatment of bleeding from esophageal varices secondary to portal hypertension.

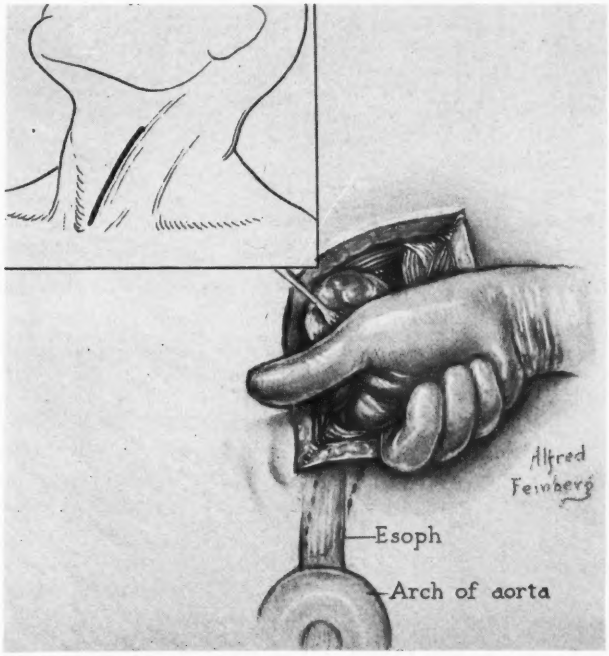

Fig. 1.—Upper mediastinal packing through cervical incision. Blunt separation of posterior and lateral surfaces of esophagus from prevertebral fascia almost to upper surface of arch of aorta.

Since our first report in which it was suggested that packing of the posterosuperior mediastinum should be tried, we have extended the operation to include, as a second stage in selected cases, packing of the entire posterior mediastinum from the arch of the aorta to the diaphragm through a right transpleural approach. Two of our patients have been treated by the latter method.

The first procedure offers no difficulties in its performance. Through a left oblique cervical incision along the anterior border of the sternomastoid muscle, the retroesophageal area is exposed by retracting the carotid sheath

laterally and the thyroid lobe mesially. The lateral and posterior surfaces of the esophagus are bluntly separated from the prevertebral fascia as far down in the mediastium as the finger will reach, usually in the neighborhood of the arch of the aorta. Into this space is packed dry plain gauze, not too tightly,

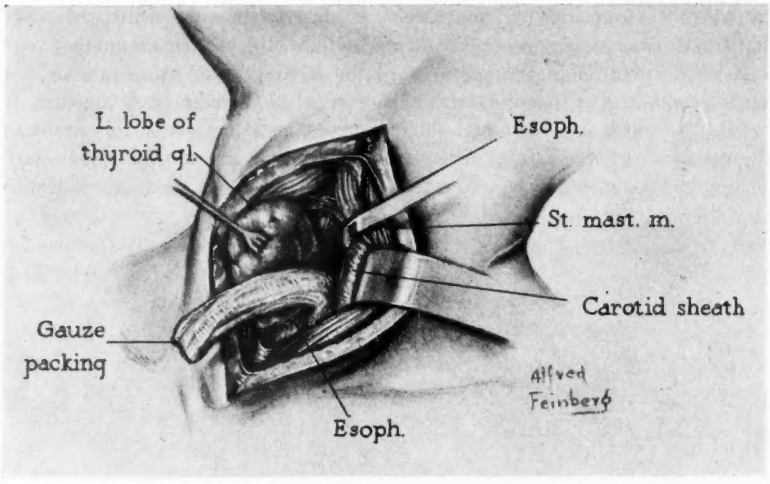

Fig. 2.—Insertion of plain gauze packing into space created by blunt dissection.

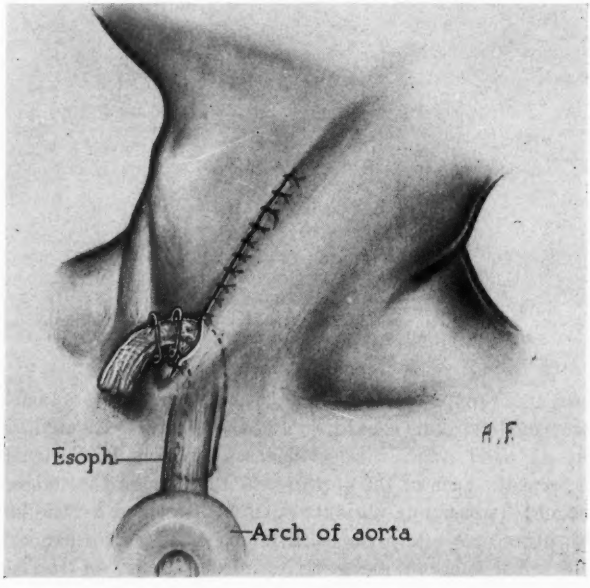

Fig. 3.—Completed operation. Gauze emerging from lower angle of incision.

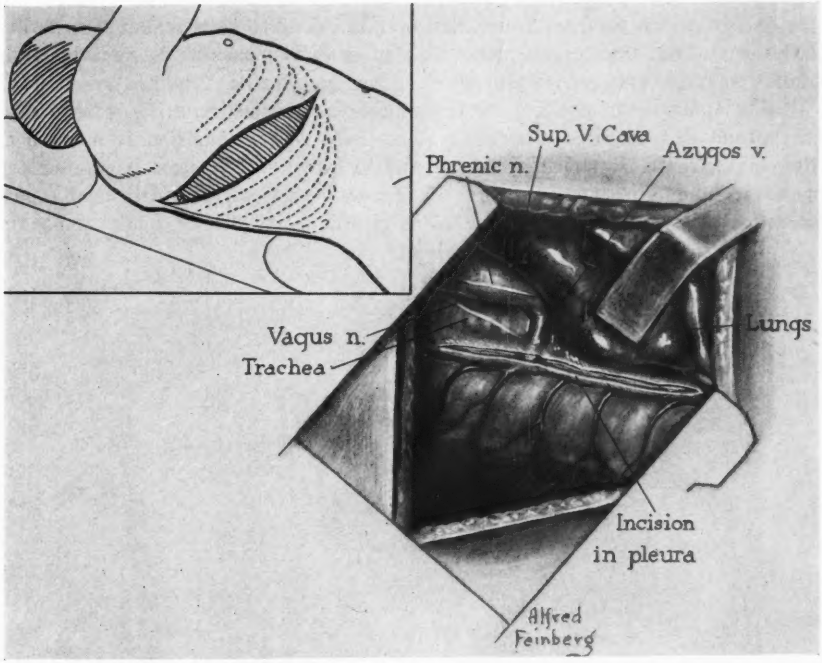

Fig. 4.—Packing of posterior mediastinum. Right transpleural approach with or without resection of seventh rib. Long incision in mediastinal pleura overlying esophagus. Fashioning of two flaps of pleura to be used for final closure.

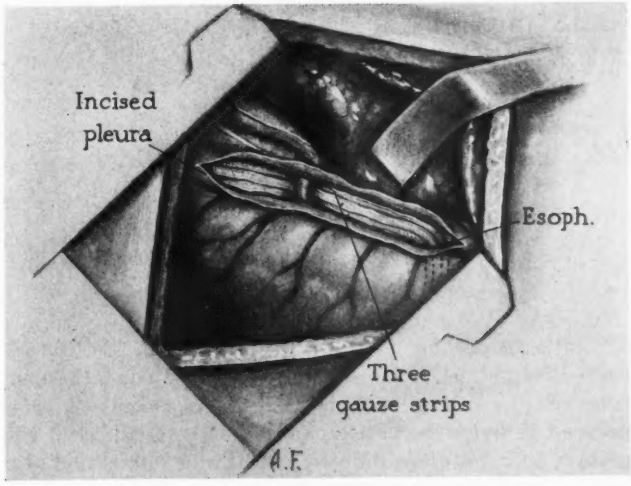

Fig. 5.—Three strips of one inch single thickness gauze packing are placed over esophagus in longitudinal direction. The emerging ends are drawn beneath lateral pleural flap in a channel created between parietal pleura and rib cage to emerge from chest wall in a subjacent intercostal space.

the end of which emerges from the lower angle of the cervical incision. The latter is sutured throughout most of its extent. The packing is removed after twelve to fourteen days without much difficulty (Figs. 1, 2, and 3).

The operation of packing the lower posterior mediastinum is one of greater magnitude and requires meticulous dissection. A long incision is made over the right seventh rib which is resected subperiosteally. The chest is entered and a rib-spreader is inserted, thus affording a clear view of the entire mediastinal pleura overlying the esophagus. A longitudinal incision is made along the

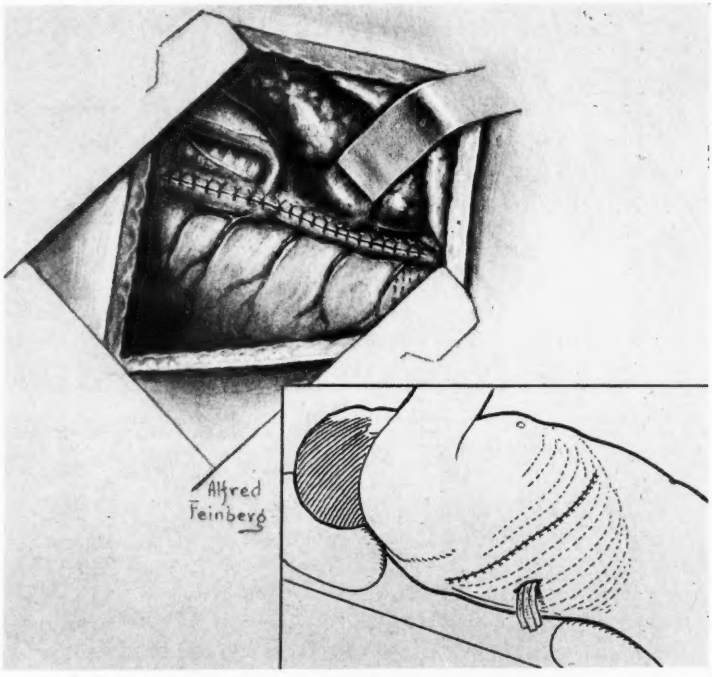

Fig. 6.—Closure of mediastinal pleural flaps over gauze packings. The latter are now completely extrapleural and emerge from the chest as indicated in the insert.

mediastinal pleura, care being taken not to injure the azygos vein. The flaps of pleura should be preserved for later use in closure. The œsophagus is now carefully freed from its mediastinal bed from the aortic arch to almost the diaphragm. In accomplishing this maneuver it may be necessary to ligate a few small veins in the mediastinum. Three strips of one-inch single-thickness gauze packing are placed longitudinally along the œsophagus. A channel is now bluntly dissected between the parietal pleura and the rib cage and the long ends of the three packings are withdrawn beneath the lateral flap of mediastinal pleura into this channel and brought out extrapleurally through a stab wound in a subjacent intercostal space. The incision in the mediastinal pleura is now repaired, thus effectively covering the esophagus and the gauze packings. The

chest is closed without drainage after inflation of the lung. The packings may be teased out of the stab wound without difficulty after twelve to fourteen days. We believe the latter should be done with the patient anesthetized (intravenous pentothal) (Figs. 4, 5, and 6).

CASE REPORTS

CASE 1 (No. 474037, previously reported[10]).—B. S. was admitted to Mt. Sinai Hospital in 1940, with a rather severe hepatitis. He made a satisfactory recovery but later began to have frequent hematemeses. He was readmitted on May 27, 1941, for esophagoscopy after demonstration of esophageal varices in the x-ray films (Fig. 7). After some difficulty

Fig. 7 (Case 1).—Preoperative esophagram showing varices at lower end of esophagus. These were demonstrated on esophagoscopy.

in passing the cricopharyngeus muscle, the tube was introduced and the esophagus examined. Many bulging varices protruding into the lumen of the lower part of the organ were visualized (M.L.S.). The patient, following withdrawal of the instrument, complained of severe interscapular pain. A roentgenogram showed air in the upper posterior mediastinum, confirming the clinical impression of instrumental perforation. A cervical mediastinotomy was performed through a right-sided incision by another surgeon. A large irregular per-

foration just below the hypopharynx was sutured loosely and several gauze packings were inserted downward into the mediastinum. The patient made a satisfactory recovery and has remained well since. He has had no bleeding in the succeeding eight and one-half years. Recent esophagrams show disappearance of the varices (Fig. 8).

Fig. 8 (Case 1).—Esophagram taken one year postoperatively showing no demonstrable varices. Esophagoscopy was not repeated for obvious reasons. (See Case Report.)

CASE 2 (No. 548020, previously reported[10]).—E. R., aged 21 years. At the age of 13 years, this patient suffered an injury to his spleen and subsequently had several episodes of hematemesis and tarry stools. In 1942, after a thorough study at Bellevue Hospital, a diagnosis of Banti's disease was made and splenectomy was performed. Six months later, the hematemesis returned and he was referred to this hospital for injection therapy of the varices. The first admission was on April 14, 1943. Esophagoscopy disclosed extensive varices at 38 cm. from the incisor teeth. Sodium morrhuate solution was injected.

A second injection was given on May 13, 1943. He remained well until August, 1943, when he had another severe hemorrhage and his hemoglobin dropped to 16 per cent. He was readmitted for repeated transfusions and was discharged two weeks later.

During 1944, he had many morrhuate injections, but the bleeding continued with increasingly shorter free intervals. He was finally admitted on Nov. 26, 1945, for the operation

of mediastinal packing. At this time the hemoglobin was 48 per cent and the red blood cells numbered 3 million. The only positive laboratory test was a one plus cephalin flocculation. Esophagoscopy disclosed numerous varices in the lower third of the esophagus, but most prominent in the region of the cardia. The esophagram was confirmatory.

Packing of the posterosuperior mediastinum was done on Dec. 7, 1945. The packings were removed twelve days later and the patient was discharged. He was well until February, 1946, when he passed a large black stool and hemoglobin dropped to 34 per cent. One transfusion of 500 c.c. of blood brought an immediate response. He was readmitted on April 22, 1946, following another hemorrhage. Hemoglobin this time was 65 per cent. Esophagoscopy at this time disclosed numerous fibrotic varices around the cardia. It was assumed that the bleeding had its origin in varices of the stomach. He gained forty pounds and returned to work. When seen on Jan. 20, 1949, three years after operation, he stated during this time he had had six episodes of tarry stools each lasting about a day. There had been no repetition of the previously severe hematemesis. It was at this time that we had decided to extend the operation to include packing of the lower mediastinum and it was therefore suggested to the patient that this operation be carried out in his case. He accepted with alacrity and was accordingly readmitted on March 3, 1949. The operation was performed on March 8, 1949, by the technique already described. An important observation at this time was the finding of an extraordinarily extensive network of vessels in the periesophageal area above the arch of the aorta, the site of the first packing operation. In the mediastinum below the arch, there were a few veins which required ligation for proper mobilization of the esophagus.

Note.—From the history, there is the strong probability that this patient's illness was traumatic in origin and resulted in a splenic vein thrombosis. The history also indicates a large alcoholic intake during the years 1942 to 1944. However, there has never been any evidence of liver damage to warrant a diagnosis of cirrhosis. It is, of course, too soon to make any statement concerning the effect of the last operative procedure, but there can be no question about the abatement of hematemesis following the original packing procedure.*

CASE 3 (No. 575135).—P. S., aged 26 years, was admitted on Jan. 8, 1948, with the story that nine years before, following a severe hematemesis, he was operated upon at another hospital and his spleen was removed for "early Banti's disease." Nine months later he had another severe hemorrhage and it was about at this time that extensive varices were demonstrated by esophagoscopy. During the succeeding seven years he had one or two episodes each year consisting of nausea, severe hematemesis, and melena requiring multiple transfusions. In the past year the attacks were more frequent and more severe. Examination was negative except for the abdominal scar. Liver function tests were negative and the stool contained no blood. The hemoglobin was 47 per cent. The polymorphonuclear leucocytes numbered 6,050, but the differential count was normal. The platelets were 400,000. Bone marrow studies revealed normoblastic marrow. X-ray examination of the esophagus disclosed extensive varices involving the lower third of the organ.

Packing of the superior mediastinum was done on Jan. 13, 1948. Convalescence was without incident and the packings were removed on the fourteenth day. The patient was discharged on January 28.

Follow-up observations.—On his first return one month later, he stated that two weeks after leaving the hospital he had had an episode of bleeding requiring three transfusions. He recovered quickly. On April 29, 1948, he stated that he had had no further bleeding and was gaining weight and had returned to work. When seen on Oct. 31, 1948, he stated that there had been noted during the preceding two weeks a drop in his hemoglobin to 48 per cent without, however, any evidence of bleeding. The stools were repeatedly guaiac negative. It was thought that some type of blood destruction was taking place to explain

*This patient has remained well to date, February, 1950, with no further episodes of hematemesis or tarry stools.

this episode. He was last seen on Jan. 20, 1949. He stated that two weeks before he had coughed up without effort a small amount of blood. This was the only episode of bleeding in a year. His general condition was excellent and the hemoglobin was 80 per cent.

Note.—This patient's portal hypertension is probably of extrahepatic origin. That there has been marked amelioration of the symptom of hematemesis there can be no doubt. A longer period of observation is necessary before a final appraisal can be made.*

CASE 4 (No. 572631).—W. B., aged 61 years, was admitted on Nov. 11, 1947, as an obvious case of rather severe alcoholic cirrhosis of three years' duration with frequent episodes of pallor, dyspnea, dizziness, abdominal cramps, and the passage of tarry stools. He had been a patient at Bellevue Hospital and was referred for the packing operation. Examination showed a pale, hyperpneic, chronically ill, elderly man. The liver was enlarged, hard and regular in outline. The esophagram disclosed extensive varices involving the lower one-half of the organ. At esophagoscopy there were seen numerous varicosities starting at 28 cm. from the incisor teeth and extending downward to the lower end where a rosette formation was found. The blood picture disclosed a severe secondary anemia with a hemoglobin of 43 per cent.

After preliminary therapy consisting of proper food intake, vitamin administration, and transfusions, packing of the superior mediastinum was done on Nov. 18, 1947. Convalescence was uncomplicated except for a mild pulmonary infection which yielded to penicillin therapy. The packings were removed on the fourteenth day and the patient was discharged soon after.

Follow-up Observations.—Two months later he stated that there had been no further bleeding. He had gained weight and had returned to work. The liver seemed to be larger. He was readmitted on Jan. 31, 1948, following the passage of a large tarry stool. The bleeding stopped following transfusion and he was discharged on February 21. On July 15, 1948, he stated there had been no further bleeding and that he felt well. On Aug. 22, 1948, he was admitted for the third time following the passage of a large tarry stool the day before. The liver was now markedly enlarged. The hemoglobin was 9.5 Gm. and the red blood cells 2,690,000; urea nitrogen, 21; total protein, 5.3; icteric index, 3; alkaline phosphatase, 8 k.a.; thymol turbidity, +; Cephalin flocculation, +. Prothrombin time was eighteen and one-half seconds (control, fifteen). He was treated with repeated transfusions. He was finally transferred to Bellevue Hospital because of the development of psychotic symptoms. According to our latest information he is at present a patient in Presbyterian Hospital.

Note.—This is a case of moderately severe cirrhosis of the liver of alcoholic origin with portal hypertension. As time goes on and experience increases it may be found that, in cases of severe portal hypertension due to intrahepatic block (cirrhosis), the packing procedure will have no effect on the gastrointestinal bleeding coming from the greater splanchnic area. When the presenting symptom is hematemesis, then the packing operation should, at least, be tried first.

CASE 5 (No. 572322).—R. C., a child 2½ years of age, was first admitted to the hospital in October, 1946, because of fever and oral ecchymoses of one month's duration. Examination disclosed splenomegaly, slight hepatic enlargement, thrombopenia, leucopenia, and anemia. X-ray studies indicated extensive varices involving the entire thoracic portion of the organ. During this stay, frequent tarry stools were noted.

He was readmitted in November, 1946, because of frequent severe hematemesis and the passage of tarry stools. Following repeated transfusions, splenectomy was done. The spleen revealed evidence of congestive splenomegaly. Convalescence was uneventful and he was discharged.

*When last seen in December, 1949, this patient was well and had had no further bleeding episodes.

During the following year, the condition remained satisfactory until Nov. 4, 1947, when he had a severe bleeding episode, vomiting a large amount of liquid and clotted blood. He was readmitted on this day suffering from acute blood loss. The hemoglobin was 5.7 Gm. Following repeated transfusions and after it was evident that bleeding had stopped for ten days, the posterosuperior mediastinum was packed through a cervical incision on Nov. 8, 1947. During the first week, convalescence was very stormy by reason of an extensive bilateral bronchopneumonia. He finally recovered and the packings were removed on the fifteenth day postoperatively. There was no further bleeding and the child was discharged on Dec. 18, 1947.

Follow-up Observations.—On March 4, 1948, two and one-half months later, there was noted a rather extensive collateral venous engorgement over the left shoulder, arm, and antecubital fossa, indicating clearly that an increased load was being thrown on the superior caval circulation. There had been no further bleeding. When seen again on April 1, 1948, the child appeared well and was developing nicely. No bleeding had been noted by the parents.

On Dec. 14, 1948, he was readmitted, following a severe hematemesis, accompanied by tarry stools. The hemoglobin was 4.5 Gm. During the succeeding ten days, he was given 3,000 c.c. of blood. Finally, after it was evident that the bleeding had stopped, packing of the thoracic mediastinum was done on Dec. 24, 1948, by the technique already described. There was noted marked dilatation and thickening of the esophagus. Approximately ten small veins were seen coursing from esophagus to the mediastinal tissues. An attempt was made to preserve these. Two strips of gauze packing were placed about three quarters of the esophageal circumference. He recovered from this operation and the packings were removed under anesthesia on the fourteenth day. He was discharged from the hospital on Jan. 28, 1949.

He was readmitted on Feb. 23, 1949, with the history that four days before he developed an upper respiratory infection. Because of the suspicion of whooping cough, a booster dose of pertussis vaccine had been given. One day prior to admission, following a severe coughing spell, he vomited a large amount of blood. Following admission, bleeding continued for some days requiring repeated transfusions. At the present writing, he is still in the hospital but doing nicely. All bleeding has ceased.

Note.—It is fair to assume that this child's basic disease is a cavernomatous transformation of the portal vein. It is well known that this variety of portal hypertension is particularly difficult to treat surgically and that the results leave much to be desired. It is encouraging to note the extensive collateral circulation over the left shoulder region, suggesting that this was produced by the first packing procedure. It is too soon to state the effect of the second operation. A further period of observation is necessary.*

CASE 6 (580355).—L. L., an Italian man, 60 years of age, was first admitted to the hospital in December, 1947, with the story of repeated hematemesis and progressive ascites of one years' duration. The work-up disclosed esophageal varices and the laboratory findings warranted the diagnosis of moderately severe alcoholic cirrhosis. He was treated medically and finally discharged somewhat improved. The second admission was on May 7, 1948, following a large hematemesis. The abdomen was filled with ascitic fluid for which repeated paracenteses were done. He had repeated episodes of esophageal bleeding requiring multiple transfusions. Finally, on May 25, packing of the superior mediastinum was carried out. Following a normal convalescence, the packing was removed on the fourteenth day and the patient was discharged.

He was well until the morning of his third admission, Aug. 16, 1948, when he vomited a large amount of blood. Examination showed the presence of extensive ascites and, by laboratory tests, failing liver function. He continued to bleed for eight days, requiring

*As of March 1, 1950, the patient continued to do well. There was one severe bleeding episode during the latter part of 1949.

repeated and large transfusions. The hemorrhage finally ceased, and his condition improved. X-ray studies revealed extensive esophageal varices extending into the stomach. He was finally discharged on September 16.

He remained relatively symptom free, except for the ascites, until Feb. 23, 1949, when he was admitted following an exsanguinating hemorrhage. The bleeding continued, did not respond to multiple transfusions, and the patient died on March 5, 1949.

Note.—As in Case 4, this was an example of severe portal hypertension due to hepatic disease (cirrhosis) with ascites. The packing procedure had no effect on the bleeding or ascites. Perhaps in such instances, in the future, packing of the thoracic mediastinum should be undertaken either simultaneously with or soon after the cervical procedure. This warrants further trial.

CASE 7 (No. 581351).—E. S., a woman 49 years of age, was admitted on May 28, 1948, with the following history. Eleven years before, following the development of epigastric pain and the finding of an enlarged spleen, she was operated upon in another hospital and a thrombosis of the splenic vein was disclosed. The spleen was not removed. X-ray examination of the gall bladder revealed calculi. The patient had previously had an attack of obstructive jaundice thought to be due to a stone. A diagnosis of polycythemia was made seven years previously and treatment consisted of phlebotomy and x-ray therapy to the splenic area. Three months before admission she experienced her first massive hematemesis. This was repeated several times and required multiple transfusions.

During the period of radiotherapy to the spleen, the patient was in the hypochromic phase of polycythemia. Her gall bladder symptoms responded to dietary restrictions. Examination disclosed a large spleen extending three fingers below the costal arch. Aside from a mild anemia, the blood picture was negative. The esophagram disclosed several large varices at the lower end of the organ.

Packing of the superior mediastinum was carried out on June 16, 1948. Convalescence was uneventful and the packings were removed on the thirteenth day. She was discharged on June 30, 1948.

We have not seen this patient since she left the hospital and moved away. We learned recently (March 15, 1949) that, since discharge, she has had two episodes of esophageal bleeding requiring transfusions and that, in February, splenectomy had been performed in Chicago.

Note.—This is a case of portal hypertension caused by extrahepatic block, thrombosis of the splenic vein. The packing of the superior mediastinum apparently had little effect on the symptom of hematemesis.

CASE 8 (No. 587914).—This is perhaps the most fascinating and dramatic case in the series. A. P., a woman 62 years of age, was transferred from New York Hospital* on Nov. 5, 1948. She had suffered from repeated hematemeses over a period of forty-one years, the onset being four months following the birth of her first child. At that time a large spleen was disclosed. Thirty-two years before this transfer splenectomy had been attempted† but the operation could not be consummated because of extraordinarily extensive venous channels. X-ray therapy was carried out without improvement. The hematemeses occurred two to three times a year and required transfusions. Fifteen years prior to admission, following the menopause, the frequency of the hematemeses increased to two a month, each averaging two to three cupfuls of blood. About this time she noted the onset of epigastric pain with the bleeding episodes. Two and one-half years before transfer, following a particularly severe bleeding bout, she was admitted to the New York Hospital

*Through the efforts of Dr. Edwin Hauser.
†By Dr. Allen Whipple.

where study revealed severe anemia, splenomegaly 10 cm. below the costal margin, extensive esophageal varices, and a duodenal ulcer. Again splenectomy was attempted but the operation was abandoned because of extreme vascularity.

After two months she was discharged for out-patient care where a mild diabetes was discovered. One year previously an active duodenal ulcer was disclosed on x-ray examination. She continued to have periodic hematemeses. In the year prior to our examination she was admitted to New York Hospital on four occasions for massive bleeding, requiring on each admission 5,500 c.c. of blood. The last admission was six weeks prior to the writing of this paper and her condition was so precarious that she required 700 c.c. of blood daily for ten days for bare maintenance. At the time she was transferred to Mt. Sinai Hospital her hemoglobin was 13 Gm.

Examination revealed a thin, poorly nourished woman. There was a loud, long systolic murmur over the precordium. The spleen was felt six fingers below the costal margin and the liver three fingers. There was no ascites. Hemoglobin was 13.4 Gm.; platelets, 40,000; prothrombin time fourteen seconds (control thirteen and five-tenths); cephalin flocculation +. A gastrointestinal x-ray series disclosed large tortuous varices in the lower third of the esophagus and a deformed duodenal bulb.

On the eleventh day of admission she began to bleed again and during the succeeding five days required 3,500 c.c. of blood. Finally, on Nov. 23, 1948, packing of the superior mediastinum was carried out. The esophagus was bluntly separated from the prevertebral fascia behind and from the trachea in front as far down as the aortic arch. Two pieces of packing were inserted practically encircling the esophagus. Convalescence was uneventful and the packings were removed on the fourteenth day. Because of some hoarseness, laryngeal examination was done and disclosed a fixation of the left vocal cord, presumably due to left recurrent nerve injury. She volunteered the information that she had not felt so well for three consecutive weeks in the preceding five years. She was discharged on Dec. 20, 1948.

She was readmitted to the Medical Service on Jan. 1, 1949, following a small hematemesis which abated promptly. She was jaundiced, and moderately ill. After thorough study, it was felt that she had homologous serum jaundice of viral origin following one of her many transfusions. She improved rapidly and was discharged on Feb. 20, 1949. When last heard from, March 17, 1949, she had had no further bleeding and, aside from ankle edema, felt well.

Note.—This is a most unusual case of portal hypertension of extrahepatic origin extending over a period of forty-one years. Two attempts at splenectomy were abandoned because of extensive intra-abdominal venous collateral channels. There has been marked amelioration of the symptom of hematemesis following packing of the superior mediastinum.*

COMMENT

To recapitulate, the patient in Case 1 has remained well eight and one-half years. Whether he would have stopped his bleeding episodes without the packing procedure is a moot question. The fact remains that varices were demonstrated before operation and were not evident upon x-ray examination one year later. The second patient has had no further hematemeses for three years. The cause of the tarry stools is probably bleeding from cardial or gastric varices. Whether or not the more extensive packing procedure will influence this, further observation alone will tell. The third patient has been markedly improved by the operation. The fourth patient with alcoholic cirrhosis has shown little or no improvement. The fifth patient, the child with cavernomatous transforma-

*It has been learned that the patient died at Bellevue Hospital on Feb. 17, 1950. The details of the last illness could not be obtained in time for publication.

tion of the portal vein has shown some improvement. The effect of the second operation will require further follow-up observation. There was no effect either on the bleeding or the ascites in the sixth patient and he finally died following a severe bleeding episode. The seventh case must be classed as a failure. The hematemeses have continued. The result in the eighth patient has been dramatic. After frequent severe bleeding episodes extending over a forty-one year period, the patient has remained symptom free.

From our observations with these eight patients, we can state that there is evidence to indicate that periesophageal collateral circulation does develop (the observations in Cases 2 and 5). It has been noted that when subsequent hematemeses do occur, they are rarely as severe or profuse as previously, indicating that some of the venous load has been taken from the submucosal venous network.*

Inasmuch as the surgical attack on portal hypertension by any method is directed at a symptom rather than the cause of the disease, we believe that the operation of mediastinal packing in its simpler and extended form should be given a fair trial before considering more extensive and more dangerous procedures. We are of the opinion that a more extensive experience will indicate eventually when the packing operation will yield desirable results and when it is contraindicated.

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DISCUSSION

DR. J. M. SNYDER, Bethlehem, Pa.—I would like to add another case to Dr. Garlock's series. This patient is a man from New York who happened to be in Bethlehem the day his bleeding started or he would probably have been in Dr. Garlock's series. He had originally been treated for cirrhosis with ascites, which had responded quite well to medical measures with the exception that he had a residual slight jaundice over a period of about two years before the bleeding first occurred. He was about 54 years of age and when he was brought into the hospital he was having a very severe hemorrhage which seemed as if it might be of an exsanguinating type and to control it, it was necessary finally to pass a balloon into the lower esophagus, inflate it, and control the hemorrhage that way.

Over the subsequent three weeks he continued to bleed from time to time and on repeated occasions it was necessary to reinsert the balloon. After thirty-one transfusions

*Dr. Arthur Blakemore, who has done a number of these packing operations, informs us that he has made this same observation.

we were running out of blood and veins, and during that time two attempts had been made at esophagoscopy with the idea perhaps of injecting the varices, but each time there was very severe hemorrhage before we had an opportunity to get near the varices with a needle. We seemed, thus, not to be gaining ground, and after having the anesthesia service help assess the patient's operability, we decided he would not stand any of the more formidable procedures. In scanning the literature I came across Dr. Garlock's article in November, 1947, in the Journal of the American Medical Association, and we decided we would try this. Beforehand we had x-ray pictures of the esophagus which showed perhaps some of the most classical heavy rugations seen with the varices which, in this case, seemed to be most marked in the middle third of the esophagus. Accordingly the patient was operated upon by the anterior approach in the lower cervical region, and instead of using plain packing I used iodoform gauze packing, and we packed the superior posterior mediastinum without difficulty; we left this in place for ten days and then slowly removed it over a period of about seven or eight days.

About a week later we took repeat roentgenograms and were greatly amazed to find a marked change in the esophageal mucosal pattern. On fluoroscopy and films the x-ray department could no longer be definitely certain that they could see the esophageal varices. The patient felt very well and returned to his home. I talked to him just before coming here; it has been three months since the original operation and he has had no further bleeding, and is feeling fine. He is to return shortly after I get back and by fluoroscopy we are going to get further films to determine the exact situation. It certainly is a procedure of considerably less magnitude and risk than the others and seems definitely worth while. He is in New York, and perhaps Dr. Garlock would like also to assist in the follow-up study.

DR. RICHARD SWEET, Boston.—It seems to me, as I reflect on this situation, that Dr. Garlock's procedure is in some danger of being thrown into the discard in the same way that various other procedures have been. I remember very clearly some years ago working on a series of these patients before the Blakemore-Lord sidetracking technique was so beautifully elaborated and, thinking I really had the answer by ligating vessels in the vicinity of the esophagus and the cardiac end of the stomach. I went so far as to have some beautiful colored pictures taken of the operation and some nice drawings made and slides available for a paper, which has never been presented. After several years I discovered that the patients had developed hemorrhages anywhere from months to years later, and some have since been apparently cured by a shunt operation.

I would like to ask Dr. Garlock how long a period of time he thinks should elapse before he feels satisfied that this procedure is worth while.

DR. E. M. KENT, Pittsburgh.—I rise only to ask Dr. Garlock a question—a technical question: Would it be feasible to substitute an absorbable gauze such as Oxycel gauze, or Gelfoam sheets, for the actual cotton gauze used in the lower thoracic approach?

DR. GARLOCK.—I did not intend this presentation to be the final word on this matter. We are groping to arrive at some method of treating a very serious symptom which accompanies portal hypertension. As I indicated in the paper, I think the portocaval shunt procedure is a physiologic one, but Dr. Blakemore tells me that he is able to employ it in only 25 per cent of the cases that come to him. This means that a large proportion of the group of portal hypertension cannot be accorded this method of therapy. It is for this reason that the method described today should be considered.

I am glad to hear from Dr. Snyder that he has had a patient who was free of bleeding for three months; that looks like a very good result and counterparts our eighth case, which will appear in the publication. We have two slides of a patient: He had demonstrable esophageal varices before operation and on x-ray examination one year later they were no longer visible. The patient has refused esophagoscopy to demonstrate it visibly but I think the films indicate that there is almost complete disappearance. The first slide shows the varices at the lower end; the next film was taken one year later showing disappearance of the varices.

We used iodoform gauze in the first few cases. The patients developed severe temperature reactions and we attributed it to the absorption of iodoform and gave it up for that reason. I think more irritation, of course, can be produced by iodoform than with plain gauze.

Dr. Sweet, I do not know how long we will have to wait; I do not know whether Dr. Blakemore knows how long he will have to wait with his portocaval shunts. This is presented as a substitute minor operation, and I think should be tried first, before portocaval anastomosis. However, I think the period of time between cervical mediastinotomy and posterior mediastinotomy should be lessened. I believe if a patient does not respond within three or four months he should have the posterior mediastinum packed as a second stage. We have had no mortality in the two cases we did, but that is a small group.

We went into the question of Gelfoam and cellulose and all the other irritating substances, but I think the experimental work done in other clinics indicates that when irritating substances which do not have to be removed are introduced, a large fibrous tissue element is formed, with a minimum of venous channels and a large scar tissue replacement. For this reason we have not used the substances mentioned.

PULMONARY ALVEOLAR ADENOMATOSIS

Cancerous Pulmonary Adenomatosis, Alveolar Cell Carcinoma of the Lung, Jagziekte?

H. Brodie Stephens, M.D., and Sidney J. Shipman, M.D.
San Francisco, Calif.

WOOD and Pierson[7] reported a case of pulmonary alveolar adenomatosis in March, 1945, the diagnosis having been made before death. The diagnosis was established in their patient by lobectomy. This operation was performed* six months prior to the patient's death. It was because of the interest aroused by this patient's illness and the fact that one of us (S. J. S.) had followed the case with Dr. Pierson, that the diagnosis of pulmonary adenomatosis was seriously considered prior to operation in the case to be reported.

Since the presentation of our paper at the Meeting of The American Association for Thoracic Surgery in March, 1949, at New Orleans, two important contributions on the subject of pulmonary adenomatosis have appeared in the literature (Delarue and Graham[1] and Swan[6]). Delarue and Graham reported the presence of an alveolar cell carcinoma in a man aged 35 years who had symptoms for approximately twelve months prior to admission to Barnes Hospital. A right lower lobectomy was performed in June, 1943, since the disease appeared grossly to be confined to this lobe. There was no evidence either at operation or pathologically of involvement of the regional lymph nodes. Microscopically, the predominant feature of the lesion was the tendency to reproduce the alveolar structure. Some areas of lung tissue showed complete replacement of the alveolar linings by hyperplastic epithelium. At the periphery of the lesion, there were occasional isolated groups of alveoli where the epithelium was hyperplastic and tended to grow in small papillomatous formations projecting into the lumen of the alveoli. In still other areas, the tendency to the reproduction of alveolar structure was not seen, the cells going wildly in clumps and cords in a loose fibrous tissue stroma. In these zones, the malignant cells showed marked variation in size, shape, and staining reaction, and mitotic figures were fairly frequent.

Delarue's and Graham's patient remained well for over three years, and in October, 1946, an x-ray examination of the chest showed a lesion overlying the right diaphragm. Right pneumonectomy was performed in December, 1947, four and one-half years following lobectomy. Actual invasion of the chest wall was present at this time. The mediastinal lymph nodes were apparently negative. The microscopic pattern of the tumor found at the second operation was very similar to that seen at the first operation. When last seen (September, 1948), the patient was in excellent clinical condition.

From the Department of Surgery and Department of Medicine University of California Medical School.

Read at the Twenty-ninth Annual Meeting of The American Association for Thoracic Surgery, New Orleans, La., March 29-31, 1949.

*By Dr. Emile Holman.

Delarue and Graham summarized their presentation by pointing out the following: (1) the neoplasm they described represents a specific type of pulmonary tumor that is characterized by a reproduction of the alveolar structure of the lung; (2) the lesion appears to be multicentric in origin; (3) alveolar cell carcinoma is a proper name for the neoplasm they describe; (4) such a neoplasm may demonstrate slow growth, but reappear several years later in a different part of the lungs, and (5) attention is called to the similarity of alveolar cell carcinoma to jagziekte, the South African disease of sheep.

Swan reported under the title "Pulmonary Adenomatosis of Man." He reviewed the cases not included in those collected by Neubuerger and Geever[4] in 1942, and presented nine cases from the files of the Army Institute of Pathology. Swan called attention to the sex ratio of approximately 1:1 in Neubuerger's and Geever's series, and the ratio of twelve men to fifteen women in the additional twenty-seven acceptable cases that he has collected since 1942. The relative predominance of this condition in the female sex resembles that of bronchial adenoma more closely than that of bronchiogenic carcinoma.

Swan suggested the term "pulmonary adenomatosis" as the preferable designation for so-called alveolar cell tumor of the human lung. If metastases occur, the term should be modified by adding the adjective "cancerous" (cancerous pulmonary adenomatosis). In addition, Swan proposed the following criteria for the diagnosis of pulmonary adenomatosis: (1) alveolar cellular proliferation characterized by the appearance of tall, columnar, mucus-producing cells, (2) absence of an intrinsic tumor of the bronchial tree, and (3) absence of primary adenocarcinoma of any other part of the body.

Swan concluded his summary by pointing out the fact that these tumors appear histologically noncancerous, but must be considered clinically to be cancers since they may kill by local growth or by metastasis. (Neubuerger and Geever estimated that 25 per cent metastasize to the regional lymph nodes and another 23 per cent to distant sites.)

Jagziekte, a South African word from the Dutch, is the name given to pulmonary adenomatosis occurring in sheep. Characteristically, the disease appears when sheep are being driven for some distance and hence the name jagziekte, or driving disease. Pulmonary adenomatosis has been recognized in the sheep of South Africa since 1893, and in addition, has been reported as occurring epizootically in sheep of Iceland, England, and the United States, particularly in certain areas of Montana. Histologically, the usually fatal ovine disease consists of a certain amount of interstitial fibrosis and epithelial proliferations forming papillary intra-alveolar masses which are noninvasive. In common with human pulmonary adenomatosis, there is multicentricity, columnar nonciliated cells, the absence of stromal invasion, and infrequent mitotic figures. Dungal[3] stated he has never seen in jagziekte metastatic growth in the tracheobronchial glands or elsewhere. No specific agent has been proved to be the cause of the disease, but many investigators have suspected that a virus is the exciting and responsible factor. Transmission of the disease is effected easily by housing healthy sheep with diseased sheep.

However, experimental infection has been generally unsuccessful. In addition, Dungal stated, in 1946, that he had not seen jagziekte in man, although many of the shepherds were in daily contact with sick sheep, often in closed houses for long periods of time, and hence every opportunity for contracting the disease was present.

The ovine disease is very insidious in its onset. It runs a chronic course so that weeks may elapse before its presence may be suspected even by an experienced observer. If the disease has not reached an advanced stage, a flock at rest containing many affected sheep may be looked at most carefully without any sickness being noticed. There is no loss of appetite, and but little loss in condition until the latest stage when the sheep are apt to become very emaciated. A cough, at first dry, is ultimately associated with the development of moist râles on auscultation. Eventually, the condition becomes productive of much secretion, at first thin and frothy which pours out of the nostrils when the sheep inclines its head towards the ground. Until or unless a terminal secondary infection sets in, the disease characteristically runs an afebrile course.

CASE REPORT

The patient was a white, married woman. She was 51 years of age at the time of admission to the University of California Hospital on April 18, 1948. Family history and marital history were noncontributory. The past history was of interest in view of the fact that in 1939 or 1940, her neighbors had a small flock of sheep. The flock became ill with an acute type of pulmonary infection from which many of the sheep died. The patient's contact with the sheep was casual, involving an interest in the misfortune of her neighbors, but not to the extent of any care of the sick animals. The patient, at no time, actually handled the sheep, but she was frequently only a few feet from them, and at times when the weather was windy and dusty. It was about this time, or shortly thereafter, that the patient noticed the appearance of a dry, hacking cough that was irritative and nonproductive. Some time between 1941 and 1942, the patient began to raise small amounts of clear, mucoid, frothy sputum accompanied by an increase in the severity of the cough. A physician was consulted because of these pulmonary symptoms. Physical examination was essentially negative, but an x-ray examination of the chest was said to show some abnormal findings in the region of the right lower lobe. Unfortunately, this roentgen film was lost and cannot be compared with subsequent roentgenograms. The provisional diagnosis at this time was bronchiectasis involving the right lower lobe. There was some progressive increase in the severity of the patient's cough from 1942 to 1945. The sputum remained mucoid and frothy, although increased in amount. A roentgen film of the chest dated June 6, 1945, showed a triangular area of increased density in the right lower lung field immediately above the diaphragm and posterior to the area of the interlobar fissure between the right middle and lower lobes (Figs. 1 and 2). Bronchoscopy at this time (June, 1945) was negative. In addition, the sputum now became thick, yellow and foul-smelling, and the patient complained of her sputum having a disturbing musty odor. There was some vague right lower chest pain accompanying this change in the quality of the sputum, but the pain was at no time typically pleuritic. Roentgen films of the chest dated July and December, 1947, revealed an increase in the size of the density in the right lower lung field, the density now being more posterior than in 1945 (Figs. 3 and 4).

Physical examination of the patient at the time of admission revealed a very well-developed and well-nourished woman appearing in good health aside from the persistent coughing. The abnormal physical findings were located in the thorax and pelvis. A slight respiratory lag was noted on the right inferiorly. Fremitus was increased posteriorly at the right. There was slight dullness over the area of the right lower lobe and in this area there were

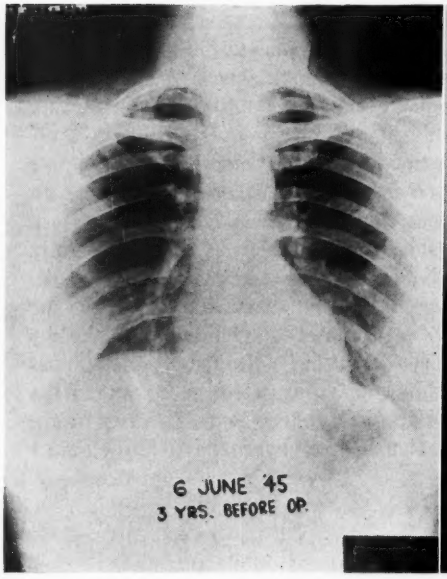

Fig. 1.

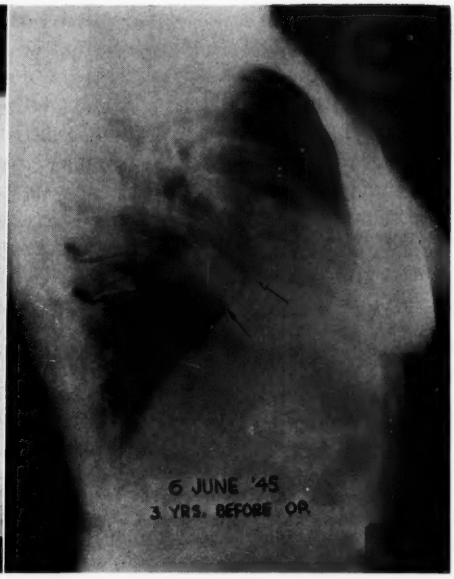

Fig. 2.

Fig. 1.—Anteroposterior projection. The triangular density is present in the periphery of the right lower lung field.

Fig. 2.—Lateral projection. The abnormal density is outlined by the two arrows.

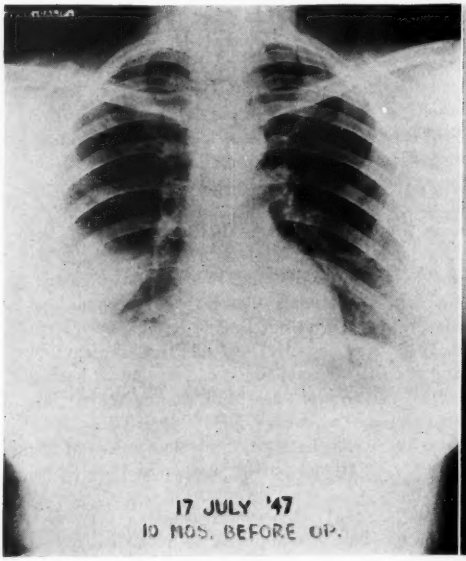

Fig. 3.

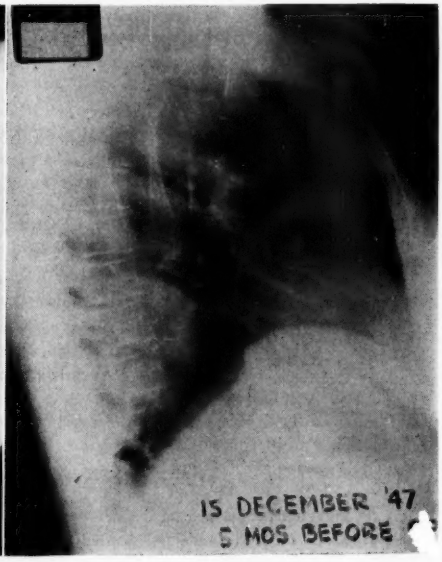

Fig. 4.

Fig. 3.—Anteroposterior projection. The density in the right lower lung field has increased in size.

Fig. 4.—Lateral projection. The density in the right lower lung field is more posterior than in 1945.

coarse râles and wheezing even after coughing. Rectal examination revealed a small fibroid tumor in the fundus of the uterus. (This tumor had been observed by the patient's local doctor for several years and has remained the same size.) The temperature, pulse, respiration, and blood pressure were within normal limits. The only abnormal laboratory finding was a white blood count of 14,150 with 86 per cent polymorphonuclears (85 per cent filamented). Numerous sputum examinations were negative for acid-fast bacilli. Bronchial smears and a single sputum examination were negative for malignant cells. Bronchoscopy and Lipiodol visualization of the right lung were carried out two weeks before lobectomy. The bronchoscopic examination was negative except for possibly some minor stenosis of the right lower lobe bronchus. All the major segmental divisions of the right lung filled normally except for possible mild cylindrical bronchiectasis in the posterior basic division of the right lower lobe.

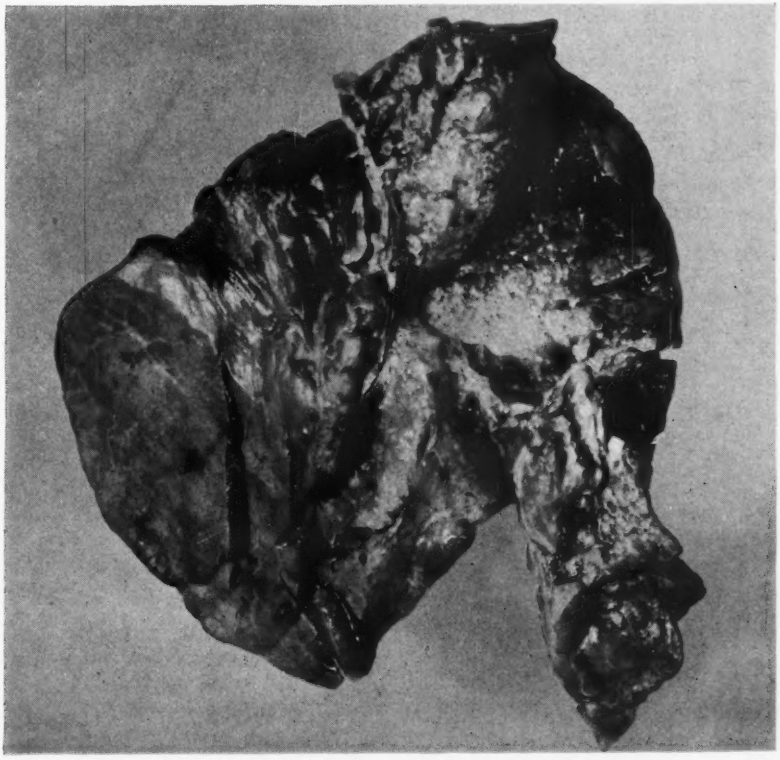

Fig. 5, A.—Gross appearance of the right lower lobe. The consolidated, waxy, gelatinous texture of the lung is depicted in the photograph.

The previous rather casual exposure to sick sheep, the prolonged insidious type of illness, to which no other etiology could be ascribed, plus the resemblance of this patient's history and findings to the Wood and Pierson case resulted in one of us (S. J. S.) entertaining the possible diagnosis of pulmonary alveolar adenomatosis. Exploratory thoracotomy was considered in order, and this was carried out on May 4, 1948 (by H. B. S.).

Operation.—When the incision was made on the right chest, there was no evidence of either pleural effusion or adhesions. The right upper and middle lobes appeared normal in all respects and aerated normally. The appearance of the right lower lobe was unique in the

Fig. 5, B.—Sagittal section of the gross specimen. The whitish areas (*A*) represent adenomatous infiltration. The darker areas of the lung in the periphery (*B*) represent alveoli distended with mucus.

Fig. 5, C.—Sagittal section of the gross specimen demonstrating the confluent nature of a portion of the adenomatosis (*A*) with a nodular dissemination in the periphery (*B*). The area marked *C* represents normal alveoli distended with mucus.

surgeon's experience. This lobe was quite free of adhesions, but firm throughout. It was salmon pink in color with a peculiar, smooth, solidified surface. The findings suggested that liquid gelatin had been allowed to fill the bronchial divisions of the lower lobe and then hardened (Fig. 5). The operation of lobectomy was readily performed because of the absence of any inflammatory reaction about the lobar hilus.

Fig. 6.

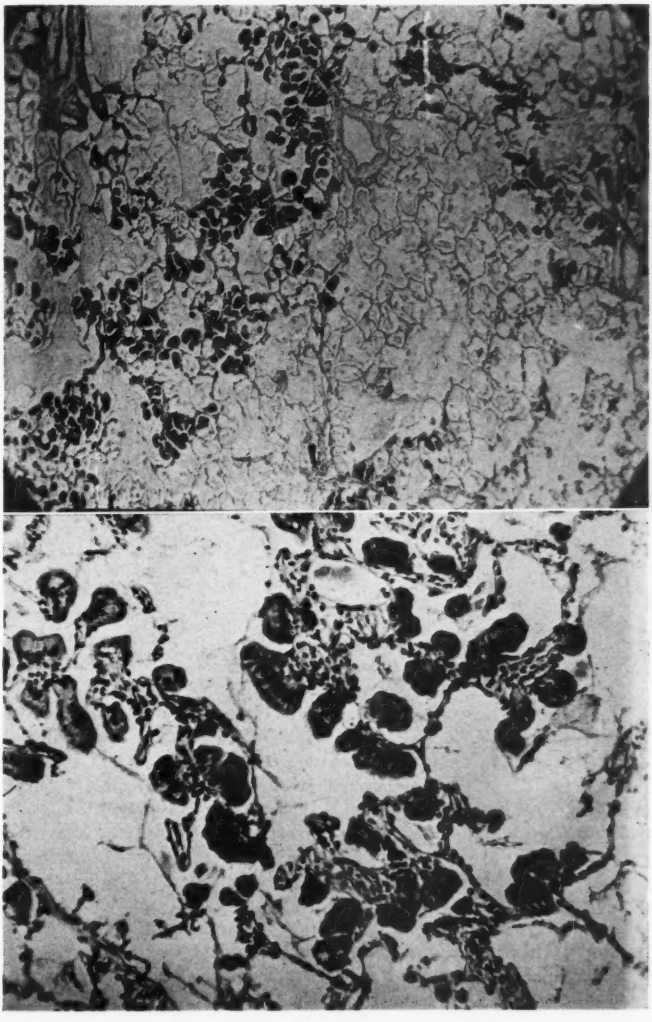

Fig. 7.

Fig. 6.—Photomicrograph of the operative specimen (×22.5). The apparent multicentricity of the adenomatous epithelial proliferation is well demonstrated. Note the apparently normal alveoli adjacent to the adenomatous proliferations. In addition, note the preservation of the alveolar framework of the lung.

Fig. 7.—Photomicrograph of the operative specimen (×100). The regularity of the cells forming the adenomatous papillary projections can be seen. There is no suggestion of invasion of the alveolar stroma, nor do the cellular proliferations completely encircle the walls of the alveoli.

Pathologic Report.—The specimen consisted of a right lower lobe, weight 470 Gm., with a smooth pleural surface. The lung parenchyma was soft and mushy with a salmon pink color. In some areas the color was pearly white and the parenchyma had a granular appearance, not unlike small granules of cooked tapioca. Often the alveoli appeared to be distended with this mucoid material. A small area of the most superior portion of the lobe showed rare, normal congested lung tissue. The bronchi were free from tumor, and a few small pigmented hilar lymph nodes were present.

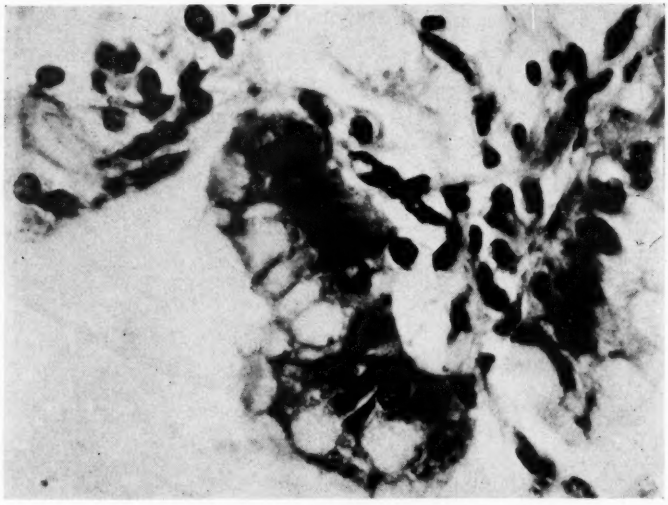

Fig. 8.—Photomicrograph of the operative specimen (×630). Goblet formation within the cytoplasm of the adenomatous proliferating cells can be seen. Note the regularity of the nonciliated columnar cells with the nuclei located in the base of the cells adjacent to the alveolar border. Appropriate stains demonstrated mucus within the cytoplasm of these goblet cells.

Microscopic Report (Figs. 6, 7, and 8).—The alveoli showed varying degrees of metaplasia and replacement by a simple columnar type of mucus-secreting cell. The cells were somewhat hypertrophic, but well differentiated, and mitoses were uncommon. Varying degrees of differentiation were present, and occasionally well-formed goblet cells were found. The cells frequently had a polypoid appearance. The alveoli were often distended by these cells. The uninvolved alveoli often were distended with mucus and mucoid containing macrophages. Occasional groups of chronic inflammatory cells were noted with early fibrosis of the alveolar walls. The bronchioles were somewhat dilated, and often contained mucus. At the margin of the more normal lung noted grossly, the pulmonary parenchyma was compressed, and the nearby alveoli were distended with large numbers of large reticulo-endothelial cells with finely granular cytoplasm. There were large numbers of eosinophils and considerable intra-alveolar bleeding. The bronchioles and bronchi in this region also were compressed, and the smaller blood vessels showed perivascular cuffing with chronic inflammatory cells and eosinophils. The pleura showed an increased number of chronic inflammatory cells. The hilar lymph nodes showed only moderate anthracosis with a slight increase in the number of eosinophils.

Diagnosis.—Pulmonary adenomatosis.

Subsequent Course.—After fifteen months had elapsed since the operation, the patient remained in relatively good health. She had maintained her normal weight, and had taken several pleasure trips both in and out of the United States. The patient continued to have a mild productive cough, bringing up frothy sputum that was mucoid in character and without odor.* Roentgen films of the chest (Figs. 9 and 10) taken three months following lobec-

*Patient's status continues the same (March, 1950).

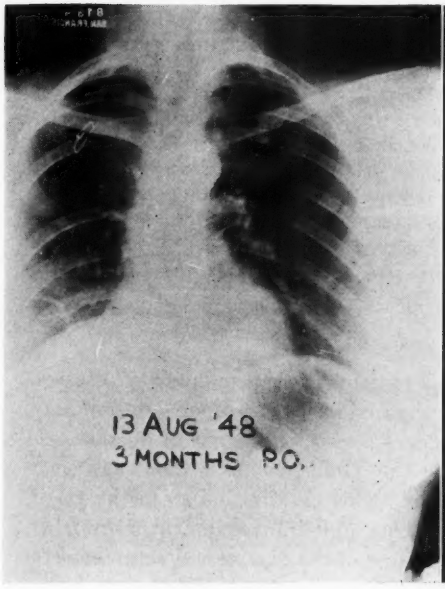

Fig. 9.

Fig. 10.

Fig. 9.—Anteroposterior projection. There is no evidence of any abnormal density at this time.

Fig. 10.—Lateral projection. Compare with Fig. 12. The lung fields appear normal three months following operation.

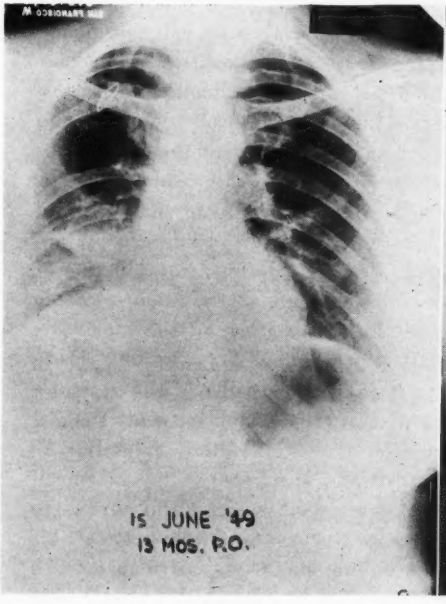

Fig. 11.

Fig. 12.

Fig. 11.—Anteroposterior projection. Abnormal density has reappeared in the medial portion of the right lower lung. In addition, there may be increase in the hilar density on the left side.

Fig. 12.—Lateral projection. Compare with Fig. 10. The abnormal density is in the lower lung field and posterior.

tomy revealed normal lung fields. Seven months following operation, an abnormal density appeared in the base of the right lung, and in addition, possible increase in the hilar density of the left lung. The patient was given a therapeutic trial of aureomycin and dihydrostreptomycin. Aureomycin was administered per os 0/5 Gm. every six hours for twenty days, the treatment beginning March 30, 1949. There was no change in the roentgen appearance of the lungs following this course of therapy. Dihydrostreptomycin, 1/0 Gm. daily (intramuscular administration) was begun May 18, 1949, and continued to June 15, 1949, without producing any change in the roentgen appearance of the lungs (Figs. 11 and 12). Bronchoscopy in August, 1949, showed a normal bronchial tree, and bronchial smears at this time were negative for tumor cells.

DISCUSSION OF CASE

It appears from the history, that this patient has had pulmonary disease for at least seven years. Lobectomy has provided a means of determining the pathologic diagnosis, but probably has not altered the course of the disease in that there appears to be progression in the roentgen films without any significant decline in the patient's well-being. This case is similar to the case reports of Osserman and Neuhof[5] and Delarue and Graham in that there is a history of long duration, an apparent limitation of the disease to a single lower lobe at the time of thoracotomy, and the histopathologic presence of multicentricity, intra-alveolar papillomatous formation, and the absence of regional lymph node involvement.

This case, per se, from the microscopic pathology presented, fits more the criteria proposed by Swan[6] for the diagnosis of pulmonary adenomatosis rather than that of Delarue and Graham for the diagnosis of alveolar cell carcinoma. In the case herein presented, under the microscope can be seen: (1) alveolar cellular proliferation characterized by the appearance of tall columnar mucus-producing cells; (2) absence of an intrinsic tumor of the bronchial tree; and (3) absence of primary adenocarcinoma of any other part of the body; thus fulfilling the criteria of Swan for the diagnosis of pulmonary adenomatosis. Delarue and Graham described alveolar cell carcinoma as being characterized by a reproduction of the alveolar structure of the lung; the microscopic appearance of the tumor in our patient fails to demonstrate true reproduction of the alveolar structure of the lung, nor is there evidence of the tumor growing wildly in clumps and cords as was the case in certain areas of the tumor described by Delarue and Graham. The similarity of pulmonary adenomatosis to jagziekte becomes particularly interesting in this case because of the patient's casual exposure to a sick flock of sheep shortly before the onset of the patient's pulmonary symptoms. The explanation may well be that the only true relationship between pulmonary adenomatosis and jagziekte is simply a specific response of the pulmonary tissue of the two species (man and sheep) to certain nonspecific irritants. As mentioned by Drymalski and associates[2] this hyperplastic response of the pulmonary epithelium may eventually cause death by extensive involvement of lung parenchyma (jagziekte) or by progressing into a true malignancy (alveolar cell carcinoma).

SUMMARY

A case of pulmonary adenomatosis has been presented. The patient's pulmonary symptoms began shortly after a definite, though casual, exposure to a flock of sick sheep. The patient was treated by lobectomy. Roentgen evidence of probable persistence or recurrence of the disease appeared seven months following operation. Aureomycin and dihydrostreptomycin in supposed adequate dosage has failed to alter the roentgen appearance of the lungs. The microscopic appearance of the operative specimen resembles more so-called pulmonary adenomatosis than alveolar cell carcinoma.

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DISCUSSIONS

DR. EVARTS A. GRAHAM, St. Louis.—I am very glad that this material has been presented. I think it of greatest importance, not with regard at the present time to the number of cases, perhaps, but it has very important theoretical possibilities. When I read the abstract, and read that Dr. Stephens apparently thought he had cured his case by lobectomy, I was sorry to see that he had made that statement. I am not surprised to note that in later x-ray examinations he found a recurrence of the lesion because that was to be expected. This is a multicentric disease, there is no doubt whatsoever of that, and because the disease happens to be attacked in a local spot, and that local spot is eradicated, there is no assurance whatever that the patient has been cured of the disease. The evidence indicates that almost certainly it will crop up in remaining portions of the lung.

The most interesting and the most important feature of this disease, however, is that although it seems to be very rare there is plenty of good evidence to indicate that we have known this disease for a good while; but it has been described under various names. At least, that is my concept. Dr. Neuhof, for example, one and one-half years ago in the JOURNAL OF THORACIC SURGERY, described this disease under the name of "Carcinoma Mucocellulare."

Perhaps Dr. Stephens regards the condition as a benign one since he uses the term "adenomatosis." Actually, the dividing line between what one pathologist might call benign, in this lesion, and what another pathologist will call malignant is so fine and tenuous that really the distinction can hardly be made. If you think that is merely my opinion, I will tell you that at the last meeting of the American Cancer Society in Memphis in January, 1949, this disease came up for consideration. It was the unanimous opinion of the pathologists present at that meeting that this disease was to be regarded as a primary carcinoma of the lung of multicentric origin, arising, I may say, not in a bronchus. It is, therefore, not a bronchiogenic carcinoma as are most cancers of the lung with which we are acquainted, but it arises in the alveoli, in the epithelium of the alveoli. We have always had some doubt in recent years, especially since Fried's work, as to whether there were epithelial cells in the alveoli, but this disease seems to indicate beyond question that there are, and that these cells can develop into a cancer.

One of the first descriptions of this disease, worked out in sheep, was made by Cowdry, of St. Louis, about twenty-two years ago. He was asked by the South African government to investigate this epidemic. At that time the disease was not known anywhere else than in South Africa. Now it has spread around the world and has involved the sheep in the United States. It is known to the sheep men by the very noneuphonious name of "snotty-nose" which characterizes the discharge. It is interesting that in Dr. Stephens' case, the human case, this same symptom was present. There seems to be little doubt about the contagiousness of the disease as it affects sheep, although inoculation experiments so far have been unsuccessful. Could it be possible, therefore, that we have now confronting us, just becoming recognized, a form of cancer of the lung which really is a contagious disease? Something which is quite different from anything that we have known about heretofore, but which probably is not nearly so infrequent as we have ordinarily thought.

In 1942, I operated on a man who had, in the right lower lobe, this disease. I did a lobectomy, and had the same difficulty at the operating table in deciding what the lesion was. Because of war conditions and depletion of staff it was impossible to get a frozen section at the operating table. I decided it was merely an inflammatory disease. I took out the lobe, and he was perfectly well for three years after this procedure. In 1946, he came under the care of Dr. Ashmore of Wichita, Kan., who found that the remaining portion of the lung was extensively involved and he advised removal of the rest of the lung, but it was not until 1947 that the patient permitted Dr. Ashmore, who is here this morning, to take out the rest of the lung. The microscopic examination of the removed portion was identical with what I had removed five years before. The other lung seems to be in satisfactory condition at this time, but there is hardly any doubt, in my mind at least, that before long the other lung will also show the same lesion.

There is one other point that is most interesting about the whole picture; that is, that this disease which you have seen portrayed this morning in the slides, is not very different from, in fact in many respects it is identical to, mouse cancer of the lung which is really a multiple malignant adenomatosis. The prevailing opinion has been that this condition is due only to genetic factors. If I had more time I would bring to your attention some reasons for thinking that actually in this inherited disease of mice which has been thought to be due merely to genetic factors we are probably dealing with a condition very similar to—I will not say identical with—but very similar to jagziekte. A virus infection, perhaps the same virus, may be responsible for both conditions.

DR. H. R. DECKER, Pittsburgh.—Dr. Stephens has brought us this presentation in a very important way, supplemented by Dr. Graham's remarks, which leaves me little to say except to present a case report to which I was introduced only three weeks ago. I think, in view of the opinion at the present time, that we might almost call this a mystery disease; certainly there is nothing in pulmonary pathology quite like it. At first these cells are orderly, there is no invasion of stroma, there are practically, in cases so far reported, no metastatic lesions. I think in the literature to which I have had access, two cases had mediastinal lymph node metastases, but in a very late situation and found at post-mortem. The importance of Dr. Stephens' presentation lies in the fact that the disease was recognized before post mortem, and my case is in the same category.

Briefly, this man, 58 years old, was shot in the chest in 1919, in a hunting accident and had a few shrapnel fragments left in the lung. In 1934, he had a very serious dental infection with osteomyelitis which gave him almost a rigid cervical spine. The significance of that will appear in a moment. In 1940, he had double pneumonia treated with sulfonamides, from which he said he made a very satisfactory recovery and was asymptomatic within six months. In 1946 following exposure to a flock of sheep ill with jagziekte, he developed pains through the chest of an irregular type, not constant, and was examined roentgenologically. It was suggested that the pain might be due to late effects of the few shrapnel fragments left therein. He developed progressive dyspnea and, in September, 1947, had a hemorrhage, rather severe, for which he was hospitalized, and within three days he had a second hemorrhage; it was said that the amount of blood lost the first time was one and one-half cups, and the second

time, one cup. The diagnosis at that time was pneumonitis with rupture of a sizeable vessel. From this pneumonia he is said to have made a recovery, but not completely because the dyspnea was still present, and in addition he had progressive pain throughout the chest. He was not incapacitated, however, and was able to carry on his occupation in a meat and grocery store.

In February, 1948, he did get to an extremity and was again studied in Chicago, where a diagnosis was made of carcinoma of the lung and x-ray treatment was advised in view of the long history. It was said that he improved somewhat as a result of x-ray treatment; he felt so, subjectively, and when I saw him his first statement was, "Under no circumstances will I allow you to do a radical operation upon me. I am interested in x-ray treatment." But it did not seem to me, that this diagnosis of cancer was completely established in spite of the fact that tubercle bacilli were not found. The sputum did not show evidence of carcinoma in the cells, and by roentgenology no differential could definitely be made of this lesion from either fibroid tuberculosis or a suppurative process, bronchiectasis or abscess without fluid level, or perhaps even fungus disease.

At any rate, he allowed me to carry out an exploratory operation for the purpose of diagnosis, and when I opened the chest I found much the same appearance that Dr. Stephens has presented. The upper lobe was entirely solid except for a periphery of aerated lung, I would estimate 1.5 cm. in width; the lower lobe had several nodules in it. When the lung was sectioned it looked iike a fungus infection or, as Dr. Stephens has suggested a gelatine transplant in lung tissue. The pathologist at our hospital, Dr. E. L. Heller, who is Associate Professor of Pathology at the University of Pittsburgh, made slides for me which I have the opportunity to show.

I would like to show first the roentgenologic series; I was able to get the picture taken in 1946, and follow the case roentgenologicaily until the present (Slides). This was in April, 1946, at the time he developed the original pain; the picture on the left was taken in April, 1947, one year later. It was stated to him that it showed no definite change from the picture of April, 1946, that the shadow noted was not significant of any trouble. I believe the disease could be demonstrated definitely at that time. The next pictures were taken in September, 1947, and October, 1947, at the time he said he had the episode of pneumonia. This was taken when he had made a symptomatic recovery. It was stated to him that there were some changes in the pleura and a certain amount of residue in the lung. The next was taken in February, 1948, in Chicago, when he was studied. No bronchoscopy was permissible because of the absolutely rigid neck. When I came to have bronchoscopy done Dr. McCullough said he had never failed to get a bronchoscope down at least into the trachea and upper bronchial tree, but he failed in this instance.

This picture was taken in January, 1949. I would feel that it is impossible from that roentgenologic appearance to make a certain diagnosis. Next is the low power appearance of the biopsy from the lung; a very widespread lesion, the alveoli are filled or almost so with these papillary projections; in this particular field there is only part of the entire lung that is not completely involved. This is the medium power presentation and shows a tremendous amount of mucin and a number of desquamated cells thrown into the alveoli. The high power picture is next. On this basis Dr. Heller felt we were dealing with malignancy definitely ingrafted on an originally benign adenomatosis. He made the diagnosis not on the basis of the irregularity of the cells so much as on the hyperchromatism in the alveoli and the fact that the cells were getting quite large and perhaps displacing one another.

I would say that the prognosis in this disease is quite definitely bad. So far as I can judge from any reading, the life expectancy from the time of development, and we do not know when it develops really, is not more than two or three years. Obviously, from the discussion already presented, surgery is not the answer. I am intrigued with the suggestion that perhaps if the disease can be diagnosed at an early time, antibiotics might have some influence against the possible virus that may be basically in the picture. I still think it is almost a mystery disease.

DR. O. THERON CLAGETT, Rochester, Minn.—I have a few points to offer which I think are of some interest. We find that this lesion occurs quite frequently; as a matter of fact, 5 per cent of the cases of carcinoma of the lung that have been examined at necropsy in our institution have been of this type. Seven of the ten cases in this group have had metastases to nodes and elsewhere. It is a malignant condition. We have seven cases that have been operated on because they were not definitely recognized as alveolar cell carcinoma preoperatively. We feel as Dr. Graham has indicated, that since it is a multicentric disease, it is not a surgical disease in most cases if its true nature can be recognized preoperatively. These seven cases occurred in the last 189 pulmonary resections for malignancy that we have done. Surgery should probably be avoided if a definite diagnosis can be made. It is of interest, I think, in our experience that this disease occurs six times as frequently in women as in men; the average age has been 51, which is certainly well in the cancer age group.

The most important contribution we have to make is, I think, our sputum studies. It has been pointed out that these patients have a thin watery secretion, and that has also been noted at bronchoscopy. We have a case in which bronchoscopic secretion was taken from each lung and malignant cells were demonstrated in secretions from both lungs. In five of our seven surgical cases Dr. McDonald made a diagnosis of carcinoma of the lung by cytologic examination of sputum; he was unable to determine its type at that time but on reviewing the experience he has with this condition at present he feels that it may be possible to diagnose this particular type of cancer by the cytologic examination of the sputum and bronchial secretions. If this can be accomplished, it will be of considerable benefit in the management of this condition.

DR. EDGAR DAVIS, Washington, D. C.—I believe that pulmonary adenomatosis is found much more frequently than the reports in the literature would indicate. For example, in September, when I reported one of my cases in Miami, there were eight additional cases reported, none of which had been previously reported in the literature. I, personally, feel it is regrettable that our tumor registry in Washington does not have more reports on these cases.

Dr. Stephens is to be congratulated on having a case so closely and definitely related to the illness of sheep. In the last three years, my former associate and I have had three such patients, two men and one women. The first patient, a woman who had never lived on a farm and had had no contact with a domesticated animal so far as could be ascertained, had bilateral disease with a mass in the right side and right-sided pleural effusion. This fluid was aspirated, and upon examination for carcinoma cells was reported positive. Had we recognized the condition at that time we could have done some interesting investigative work, such as injecting the fluid into mice, guinea pigs, and rabbits, to ascertain whether or not we could transmit the disease to other animals.

The second patient was a man who did live on a farm but who had no sheep nor hogs, so what his source of infection was, no one can say. The third patient, whom I shall report later, was an operative case.

(Slides.) These slides are of a 63-year-old white man who had lived on a dude ranch in Nevada for about six weeks. However, he had not come in contact with any sheep and had not eaten at the ranch, he and his daughter having driven to town for all of their meals. The bronchogram demonstrates a perfectly normal distribution and pattern of the bronchial tree without evidence of bronchiectasis. At bronchoscopic examination I was amazed to see the amount of thin, bubbly, mucoid secretions coming from the left-stem bronchus. The secretions showed what was called carcinoma cells. The next slide is a photograph of the specimen, showing multiple adenomatous nodules in the periphery. The next slide is a photomicrograph of the specimen the patient coughed up two days after the bronchoscopic examination. A number of pathologists have examined it and all of them have called it carcinoma.

I have with me a report from Dr. Smetana of the Army Institute of Pathology, that might be both interesting and instructive. He has given me a report on eleven cases; nine of them have already been completely worked up and have been reported by Dr. Swan in an issue

of the Archives of Pathology, which will soon appear. Of the nine, eight were diagnosed at the time of autopsy. The other patient, who had a lobectomy, is still alive but shows definite evidence of recurrence in both lungs.

The two additional cases recorded at the Institute of Pathology are not completely reported. One was diagnosed at autopsy, and one was the patient I have reported, who remains well seven months after surgery.

DR. ROBERT T. FOX, Hines, Ill.—I wish briefly to report a previously published case, presented by the pathology department of the Municipal Tuberculosis Sanitarium in Chicago. Three patients were reported upon, one of which had right lower lobectomy. That patient died one and one-half years later of multiple distant metastases showing the same histologic picture as the primary lesion.

We at the Veterans Administration Hospital at Hines, Ill., recently had a case which differs from the others in that it was a fairly rapid course, some 6 months from onset of symptoms to death. The predominant symptom was the marked bronchorrhea, amounting to some three or four quarts of watery sputum daily (slides).

This shows the lesion in the left lower lung field, somewhat similar to an interlobar effusion; however aspiration was of no avail. This patient refused exploration. He was in fairly good condition early in hospitalization but would not submit to operation. After about two months there was increase in the lesion on the left side and evidence of a fairly typical bronchiogenic spread on the right. His course was down hill and he gradually suffocated. We are glad he refused surgery in view of the present discussion. The gross specimen was much like gray hepatization or the very descriptive term of gelatine infusion. Pus could not be scraped from the surface, however. The photomicrograph shows typical papillary structure. The high power is similar to that previously described.

DR. STEPHENS.—I want to thank the members for this excellent discussion. Of course, we always enjoy Dr. Graham's remarks, and I was happy to hear that he is somewhat intrigued by the possibility that this may be a malignant tumor which has multicentric areas of stimulation due to irritation from a virus. Certainly it has been true in the papillary warts and it may again be true in this disease and opens up interesting channels for future investigation.

PLASTIC RECONSTRUCTION OF TUBERCULOUS BRONCHOSTENOSIS WITH DERMAL GRAFTS

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HONOLULU, HAWAII

PRESENT day tuberculosis of the trachea and bronchi as seen in living patients alters some of the conceptions of the disease gained from voluminous post-mortem studies of the past. Clinical and autopsy findings indicate a higher incidence in women, a more frequent stenosis of the left bronchus, and a parallelism between involvement of the air passages and advanced, extensive disease of the lungs. Beyond this there is no constant relationship between the location and severity of the tracheobronchial lesion, and the location and extent of the parenchymal disease.

THE STENOSIS

Tuberculous lesions may occur anywhere in the air passages. They do not predominate on the posterior membranous surface. They may involve the circumference of a short segment of a bronchus, or its whole length. Advanced bronchial disease is sometimes encountered in patients with clinically uninvolved lungs. Tuberculous ulceration may be present in the left bronchus while extensive lung disease exists on the right (Fig. 1).

If the pulmonary disease is compatible with life, and especially if it is controlled by treatment, tracheobronchial lesions tend to heal. A small mucosal ulcer resulting from caseation of a submucosal focus may heal without grossly discernable scar. If the elastica is destroyed, healing produces a puckered scar and mild deformity. Breakdown of coalescent caseous foci produces the type of ulceration seen at autopsy and popularized by textbook illustrations. Such extensive lesions in living patients are now rare, and more rarely they heal with the formation of fibrous scars which produce gross deformity of the airway cross section. Whenever inflammation involves the thick, fibrous layer housing the cartilage rings, cicatricial contracture and stenosis always accompany the healing process, because of the natural architecture of the trachea and bronchi. Collapse of the fibrous bronchial wall is caused by dissolution of the supporting cartilages secondary to destructive chondritis. Simple collapse and contraction resulting from loss of supportive framework probably has not been allotted due attention in the pathogenesis of bronchostenosis. Under such circumstances healing of a severe mucosal lesion alone may produce stenosis, without destruction of the fibrous and elastic elements of the bronchial wall, or without the excess production of scar tissue. On the other hand, at operation, caseation of the entire bronchial wall is occasionally encountered, and frequently fragmented or necrotic cartilage is found. If it is borne in mind that tuberculosis heals by the conversion of cellular exudate to fibrous tissue, and by the proliferation of

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granulation tissue which matures to fibrous tissue, the observation of advanced bronchial destruction makes dense scars and extreme stenoses easily understood. Similar scarring occurs in the lung parenchyma, the pleura, and the pericardium by virtue of the natural healing response to tuberculous, or granulomatous infection. When the architectural weakness of the bronchial wall is added to such pathologic changes, it must be deduced that severe tuberculous tracheobronchitis either produces the extensive ulcerations revealed at autopsy, or, when the patient lives, bronchostenosis.

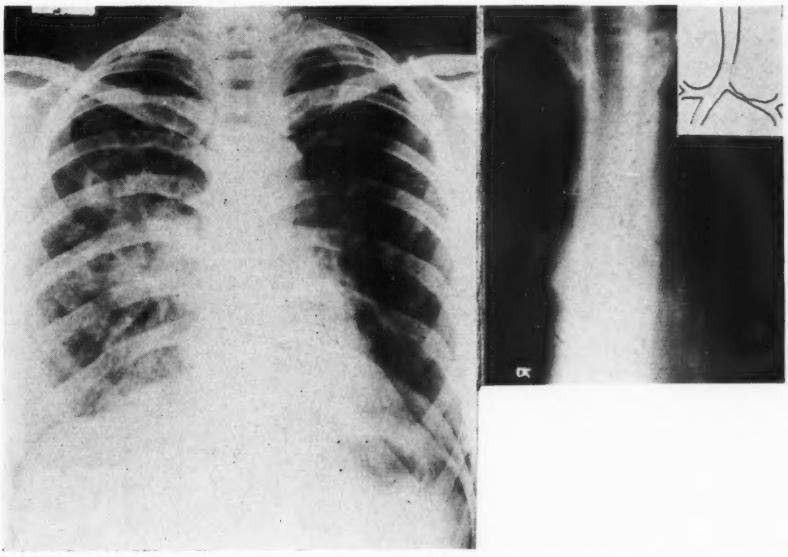

Fig. 1.—Example of contralateral bronchial disease. The extensive disease on the right indicates resection. The left lung is in a good, healed state despite the rather severe bronchostenosis revealed in the planigram.

The presence of stenosis itself does not signify complete healing of a given lesion. However, if, through the bronchoscope, acute ulcerations and inflammations are observed to progress to clean, smooth, stenotic scars, and to remain such, they may be regarded as healed despite the possible persistence of active tubercles in the fibrous scar. Only the upper end of a stenotic bronchus can be viewed. If it appears healed, the remainder of that bronchus is also likely to be healed, especially if the clinical course of the patient and of the lung is favorable, and the sputum is mostly negative. While a stenosis of a given bronchus is usually in a uniform state of healing, the bronchi beyond it may be in any state. This is particularly true of the upper lobe bronchus, and its immediate branches. Active caseation may be found in the upper lobe bronchi, while healed stenosis exists in the main bronchus. In fact, these circumstances should be suspected whenever the sputum is usually positive, the visible bronchial lesion apparently healed, and no open lesion exists in the lung fields.

As intimated previously, consideration of the effect of dissolution of the supporting cartilages indicates that severe stenosis can occur without preceding extensive destruction of the bronchial wall. More often than not, this concept is supported by operative findings. Frequently the stenosis is a contracture of the bronchus itself. The surrounding lung stroma and mediastinal structures are quite readily separable from the diseased bronchus by surgical dissection. Figs. 2 and 3 are illustrative. Certainly, peribronchial inflammation and scar are not essential for the production of bronchostenosis. Less commonly, extramural scar contributes to the stenosis; sometimes the hilar structures, particularly the pulmonary artery, are encased in hard scar. Such changes follow extensive, deep destruction of the bronchial wall. Fig. 5 is an example. In some instances lymph node perforation of the bronchial wall is a possible etiologic factor.

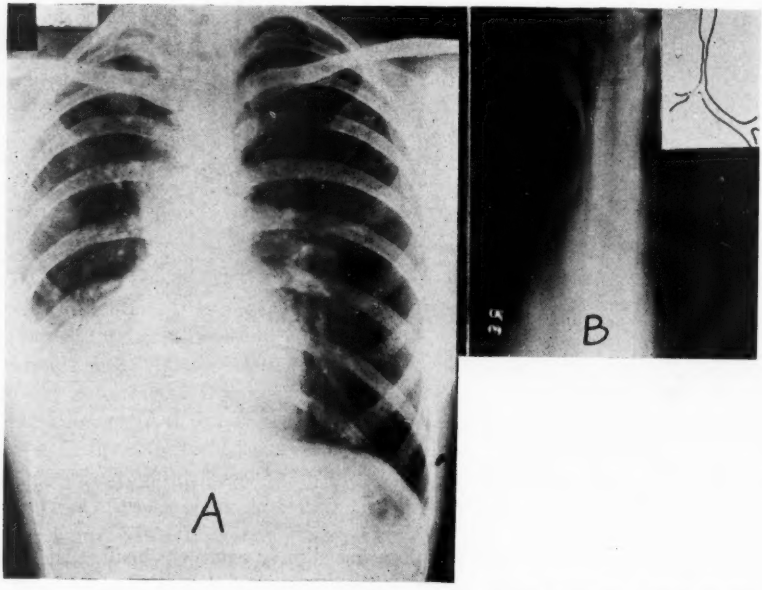

Fig. 2.—Example of severe stenosis resulting from purely intrinsic disease of the air passages. *A*, Atelectasis and destruction right middle and lower lobes, some infiltration in the upper lobe; left lung is clear. *B*, Extreme stenosis of the thoracic trachea, resulting from extensive ulcerocaseous tuberculosis. Healing was observed bronchoscopically during and after treatment with streptomycin.

The posterior membranous portion of the larger bronchi contains no cartilage. Healed lesions here are narrow and contracted, but not to the same extent as the remainder of the bronchial circumference. The element of wall collapse is lacking, and the resultant difference in the disposition of scar tissue found at operation is sometimes striking. The same disparity does not occur in surgical specimens exhibiting tuberculous stenosis of small branch bronchi, where cartilage plates are irregularly disposed about the whole circumference. The inequality in the degree of scar may not be due to the absence of cartilages posteriorly. It may be due to a difference in healing properties, or in blood

supply. Regardless, it is a frequent observation, and, in addition, linear incision of a stenotic bronchus usually reveals a more intact mucosa, and less exudate on the membranous portion in contrast to the anterior and lateral walls.

Because of the more favorable pathologic changes, and because of its surgical accessibility, the posterior membranous surface of the trachea and bronchi is considered the most suitable site for surgical attack.

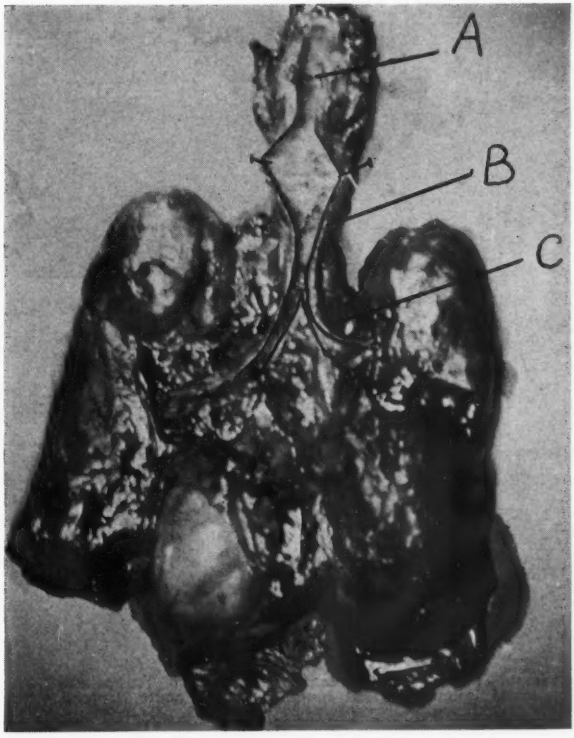

Fig. 3.—Posterior aspect of thoracic contents of patient in Fig. 2. The membranous tracheal wall was almost normal; the paratracheal tissues were particularly clean and free of scar. The hilar structures around the stenosis of the distal right main bronchus were easily separated by dissection. *A*, Larynx. *B*, Trachea. *C*, Right main bronchus.

THE LUNG

If a bronchostenosis is severe enough, or present long enough, functional impairment and subsequent destruction of the respiratory system beyond the stenosis eventually occurs. The pathologic changes distal to a stenosis are dependent on many interrelated factors besides "resistance and virulence." Some of these factors are the extent and course of the parenchymal disease when the stenosis first becomes obstructive, the amount of secondary infection present, the rate of progression, and the degree of obstruction, the effects of treatment, such as lung collapse, and the volume of lung tissue affected by the

stenosis. None of the changes resulting from stenosis are beneficial, and the usual elements of the combine which eventually destroys the distal lung tissue are atelectasis, fibrosis, progressive tuberculosis, bronchiectasis, nonspecific pneumonitis, and abscess formation. Any one process or any combination may dominate the clinical picture, which is as variable as the responsible processes. However, these variations are more those of degree than of kind, for in general all the pathologic changes are destructive and progressive. The progression may be slow or rapid. Regardless of the mechanism of destruction, lung function is lost and illness is the patients' lot. Among the various clinical states produced by such illness, the following types are clinically prominent.

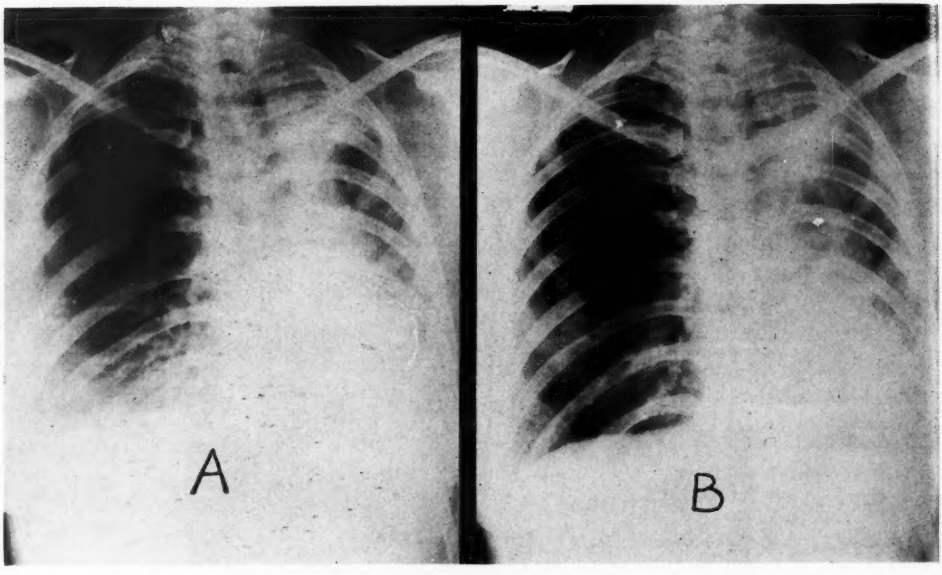

Fig. 4.—Example of Group 1, representing extension of parenchymal disease during active phase of bronchial lesion. *A*, Left lung destroyed; acute "spread," and fluid base of right lung. *B*, Clearing following streptomycin.

The first group of patients have rapidly progressive tuberculosis. The lung involvement is usually extensive and advances in step with the stenosing process in the bronchus. By the time the bronchial lesion is converted from an ulcerocaseous phase to stenosis, the lung disease is far advanced. The only hope is to bring the patient to a point where excision of the bronchus and its constituent lung can be done. The patient presented in Figs. 4 and 5 is an example. Streptomycin cleared the right lung and brought the tracheobronchial lesion to a surgically receptive state.

The second group of patients have healed or mildly active bronchial lesions. Their lung disease may be little or advanced; in either case, it is progressive and contraindicates any attempt to relieve the stenosis surgically. Sometimes the progression is rapid, especially during, or following a period of atelectasis.

In the beginning, episodes of atelectasis are intermittent, and frequently influenced by attempts at collapse. Some lung segments may be spared; frequently lung segments and lobes quite free of disease are "shut off" by the stenosis. Later on, atelectasis either becomes persistent with its usual consequences, or one of them, such as bronchiectasis, dominates the picture (Fig. 6). Up to this point resection of the involved lung and its stenotic bronchus is clearly indicated.

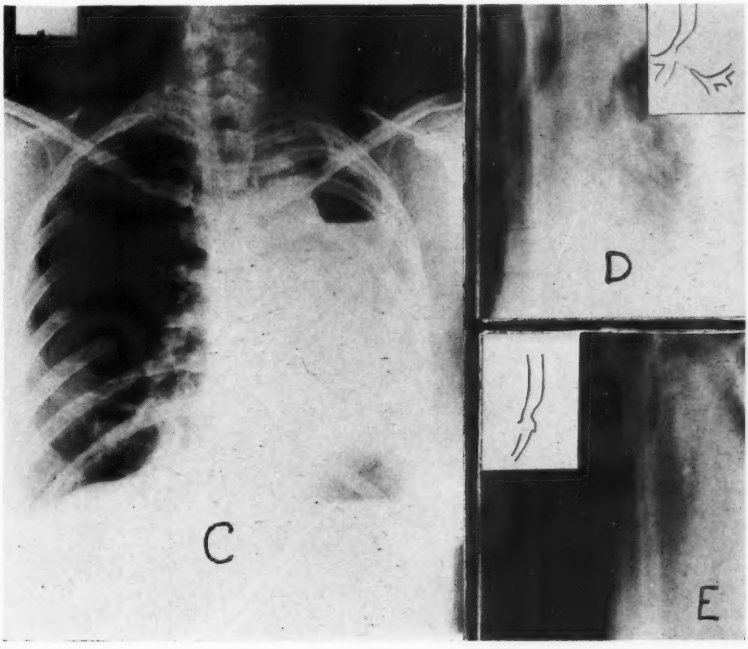

Fig. 5.—*C*, Patient of Fig. 4, after left pneumonectomy; also an example of extramural tissues contributing to stenosis; no "flare-up," right base. *D*, Planigram before operation showing stenosis of left bronchus and lower trachea. Immediately after removal of the left lung and its hilar scar, it was possible to advance a 32 French intratracheal catheter into the right bronchus. Bronchoscopy before operation had revealed a 6 mm. lumen in the lower trachea. *E*, Planigram after operation demonstrates the increase in tracheal lumen after resection of extramural scar.

Now and then healed stenosis of the main bronchus is accompanied by parenchymal disease, static or progressive, which remains confined to the upper lobe while the remaining lobes are free of disease, and unaffected by the main bronchial lesion. Such circumstances are not uncommon; however, they do not exist forever, and sooner or later the good lobes succumb to the stenosis through which they must function. If patients can be detected clinically before this, resection of the diseased lobe and reconstruction of the airway to the good lobe is considered more rational treatment than excision of everything distal to the stenosis. Cases 1 and 2, cited later in this report, belong to this group.

The third group of patients have healed bronchostenosis with functional or organic occlusion. The component lung is atelectatic and usually consists of

a small fibrotic mass containing "burned out," or healed disease, or encapsulated caseous foci. The patients have negative sputa and are clinically well. Such conditions represent the ultimate in natural healing and are common in small segments of lung. An entire lobe may heal in this fashion, but rarely does a whole lung. When a large or a main bronchus is occluded, some degree of

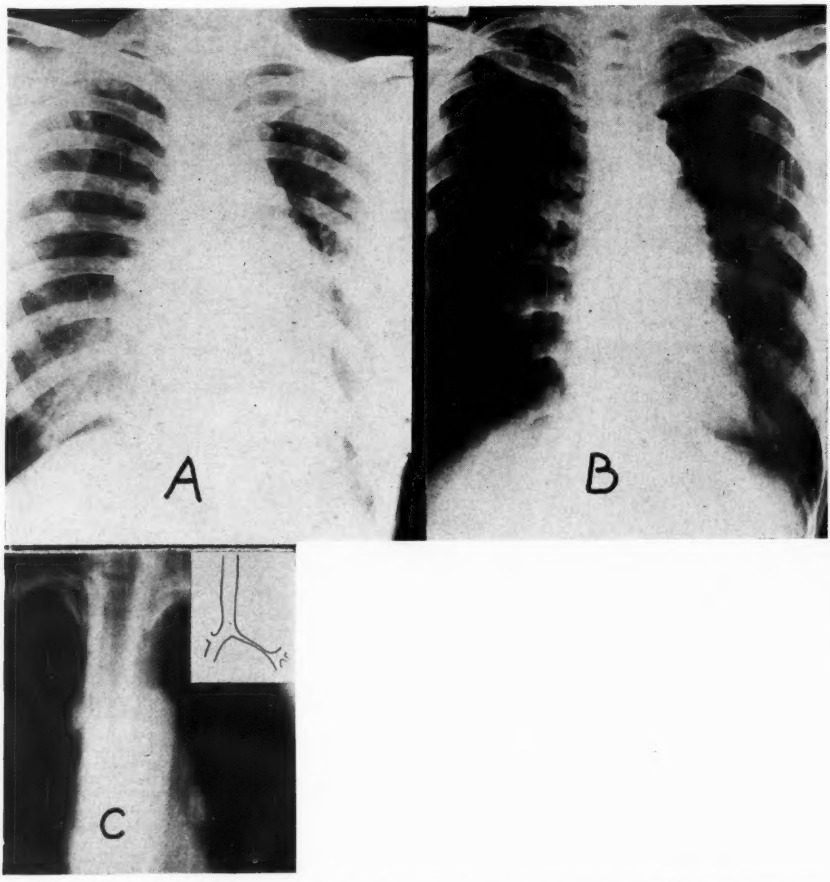

Fig. 6.—Example of Group 2. *A*, Episode of left lower atelectasis with marked symptoms. *B*, Spontaneous clearing four months later. *C*, Planigram illustrates left bronchostenosis. The left lung cleared further with intensive antibiotic therapy, but pneumonectomy was indicated because of irreversible bronchiectasis of both lobes, and unhealed tuberculosis in the upper lobe. The stenotic bronchus was well healed and could have been reconstructed. This was contraindicated by the previous findings, which were established by complete bronchotomy, as well as by subsequent examination of the surgical specimen.

infection usually supervenes and the chain of events leading to lung destruction begins. Even with insignificant infection bronchiectasis occurs. Case 4, cited later, belongs in this group.

Most patients in the third group have fairly good resistance and have done their share of "curing." Nevertheless, they all pass through a stage when

healing is not complete, during which they actually belong in the second, or previous group. It is inadvisable to wait for ultimate, natural healing in stenosis of a lobar bronchus, because of its rarity. If the bronchus is occluded the component lung is useless and chances are it will not remain innocuous. Lobectomy should be done, providing the remainder of the lung on the same side is clinically "healed" or free of disease. Certainly, natural healing should not be awaited hopefully in main bronchial lesions. If the lung is diseased it should be removed; if it is in a good healed state, reconstruction of the stenotic bronchus seems clearly indicated.

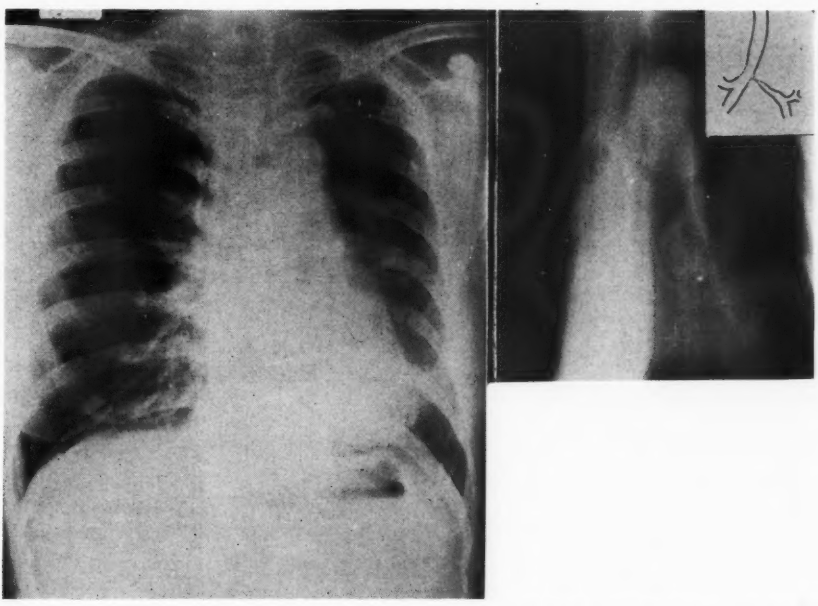

Fig. 7.—Example of Group 4. The left lung is healed with some fibrosis. The stenotic left bronchus had a 3 mm. lumen at the carina, not enlarged by repeated dilatations. The patient has negative sputum, a persistent wheeze, intermittent cough, and diminished breath sounds. Reconstruction of the left bronchus, rather than pneumonectomy, seems indicated.

The characteristics which make the fourth group of patients clinically prominent are healed, quiescent, or minimal lung disease, and a healed, stenotic bronchus. A minimal airway exists permitting lung aeration. Over a period of months or years, episodes of sputum block, intractable cough, atelectasis, and dyspnea occur with irregular frequency. Except for cough and wheeze, the true disability is periodic, but every bout of atelectasis, and every "cold" hazards a "setback," "spread," or further lung damage. The ultimate prognosis for a given lung is doubtful. Some degree of functional impairment is always present, and the passage of time leads to increasing impairment secondary to fibrosis, atelectasis, bronchiectasis, and so forth. In many of these patients tuberculosis produces a scar in the bronchus and lung, and then drops out of the picture. The offending agent is a structural deformity of the air passage invoking a chronic, recurring disability for which most patients willingly

submit to excisional surgery. This relieves their symptoms. Also, it frequently relieves them of considerable volumes of good lung tissue, and that is the trouble. Pneumonectomy or lobectomy should be performed forthwith when the lung or a lobe is diseased, but one hesitates advising removal of a good lung because its air passage is stenosed, even with the suspicion that matters will get worse as time goes on. Figs. 7 and 8 illustrate two patients in this group.

The preceding rather gross evaluation of the clinical circumstances ordinarily obtained from healed or healing tuberculous bronchostenosis designates a number of clinical states in which reconstructive surgery of the air passages seem highly desirable.

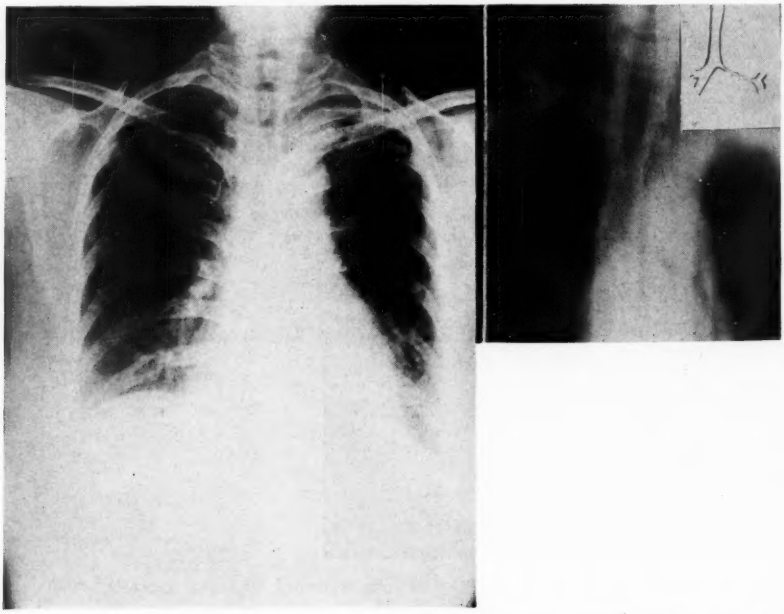

Fig. 8.—Another example of Group 4. Scattered, healed disease, possibly some bronchiectasis, exists on the left. The planigram shows stenosis of the left bronchus. Symptoms are a rather severe, persistent cough, wheeze, and episodes of sputum block. Sputum has been negative for over one year. Reconstruction of the left bronchus is indicated.

PROPOSAL

The surprising healing and regenerative powers of the epithelium and other wall structures of the dog's trachea and bronchi have been demonstrated by Taffel,[1] Hanlon,[2] and Daniel.[3] In the experimental laboratory, the growth of epithelium over degenerating fascia, gelatin sponge, and totally foreign substances, as well as the regeneration of cartilage rings about such structures as glass tubes, have been observed, indicating a healing response of these tissues beyond ordinary expectation.

In addition to these favorably prophetic experimental findings, certain clinical facts suggest that the human trachea and major bronchi have similar properties, and might be highly receptive to reconstructive surgery. Clean,

primary healing of an amputated bronchus can always be expected if it is handled carefully, sutured accurately, its blood supply preserved, and infection avoided or controlled. Uncomplicated bronchotomy and suture, despite the presence of some infection, has been reported in man.[4, 5] Belsey[6] briefly reported an instance of tracheal reconstruction with a fascia-wrapped spiral of stainless steel wire. Gibbon[7] mentioned the filling of a tracheobronchial defect with a segment of costal cartilage wrapped in a pedicle of parietal pleura. Finally, excisional lung surgery has shown that the healing of a bronchial stump is enhanced by the formation of scar arising from the adjacent lung, pleura, or mediastinal tissues. In fact, sometimes a large portion of the scar of a healed bronchial stump grossly appears to have been contributed by these structures, or by the organization of blood clot which they support. Such findings suggest that the mediastinal bed of the air passages has good sealing and healing properties of its own. On the basis of experimental observations and clinical experience, it seems logical to expect plastic procedures and grafts of the bronchi to be feasible and practical.

Any substance used in bronchial grafts should meet certain essential requirements. First, it should provide an adequate, air-tight passage. Second, it should afford a semirigid, noncollapsible support. Third, it should serve as a scaffold for the regeneration of epithelium. Fourth, and finally, an ideal graft should survive as living, transplanted tissue, and, at the same time, provide wall structure. This final requirement is not considered completely essential for a good ultimate result. Failing to "take" in entirety, a graft could still function as a foundation for natural healing and regeneration. It could provide a framework for such processes during its disintegration and replacement. Fascia and Gelfoam apparently behave in some such fashion in the experimental animal. Actually, it is possible that metaplasia, and even metamorphosis, might occur in any type of grafted tissue, so that ultimately it would simulate the neighboring bronchial structures.

The dermal layer of the skin probably fulfills the preceding requirements better than any other living tissue. Its properties, and the properties of whole skin used in place of fascia, or buried to fill defects, are recorded in medical literature. May and Spann[8] have summarized the early use of the dermal graft. In personal experience, it has been found useful as a heavy ligature for partial occlusion of the thoracic aorta above an aortic aneurysm, or as a bronchial plug, anchored with wire sutures, into the bronchial fistulas of exteriorized lung cavities. A rapid "take," and the growth of epithelium over the dermal plugs, has been perceived in such instances. The dermal skin is thick, tough, and elastic. It is rich in vascular and lymphatic channels. It is naturally designed for the foundation of a surface. It holds sutures tenaciously; it does not separate or tear when pierced with a needle, as does fascia, pleura, or epidermis. For these reasons, and because of its thickness, it is well adapted for airtight suture lines. When applied to a bronchus as an inlay graft, the cut surface of the deep epidermis and the skin papillae are presented to the bronchial lumen. This surface forms a suitable bed for the ingrowth of bronchial epithelium. Should this fail to occur, new squamous epithelium can regenerate from the papillae, thereby affording a good opportunity for metaplasia. If the epidermis

were not removed, it would probably slough off and be expectorated. Until then, a suitable surface for the ingrowth of bronchial epithelium would be absent. For the above reasons the derma is recommended for bronchial grafts, and is considered superior to full thickness skin.

TECHNIQUE

Dermal skin fulfills all the proposed requirements except semirigidity. This can be provided by stainless steel wire when it is laced through the graft, as depicted in Fig. 9. This disposition will not prevent give and motion in either axis, so that some degree of pliability is preserved. The technique of dermal grafts to the main bronchi is illustrated in Figs. 9 and 10. Experience to date has uncovered some details that might be useful to those interested in performing the procedure.

The face down, prone position, with the operated side tilted lowermost, is unquestionably the best. It permits a direct posterior exposure, reduces mediastinal motion, and prevents "spill" to the good side.

Exposure on the right is simple. On the left it is usually necessary to mobilize the aortic arch for adequate exposure of the lower trachea and bifurcation. Such mobilization is likely to injure the recurrent laryngeal nerve unless it is identified and protected.

The esophagus tends to bulge into the field and must be retracted; this frequently exposes the thoracic duct which can be protected with a pack. Frequently, the pulmonary artery is involved in an upper lobe bronchial scar, and separation injures it. It must be preserved. This has been accomplished by temporary occlusion with a soft clamp, and the application of a small patch of Gelfoam held in place with overlying arterial sutures taken in the adjacent arterial wall.

Before incision of the stenotic bronchus, the intratracheal catheter is advanced by the anesthetist, and guided into the opposite main bronchus with a palpating finger. After the bronchus is opened, it is carefully inspected, washed with streptomycin-penicillin solution, and packed with gauze soaked in the same solution. In the meantime a suitable dermal graft is fashioned from the ellipse of skin removed at the primary incision.

The graft should be cut somewhat larger than would be expected. It does not have to be stretched taut. It should come to abrupt ends. The loops of wire (28 gauge) should be wide enough to provide a fairly round contour to the graft. This is most important, for insertion of a flat graft will produce a wide slit, rather than an open lumen. The width of the graft, therefore, is determined largely by the width of the wire loops. The elastic derma should be about the same width, but does not have to be wider. A graft ¾ inch wide will form a ½ inch lumen diameter when it is curved into a semicircle. The size of the graft is a matter of judgment as well as measurement. It depends on the width of the opened bronchus, and its shape. If the posterior bronchial wall is thin and retracts, leaving a flat scar, the graft will have to be wide with a full curve. If the bronchus itself has some curve and is fairly wide, the graft

can be more narrow and less curved. The length of the bronchial incision is measured and a pattern cut from paper, which is curved and approximated to the bronchial defect. The graft is cut somewhat larger on all sides. The wire

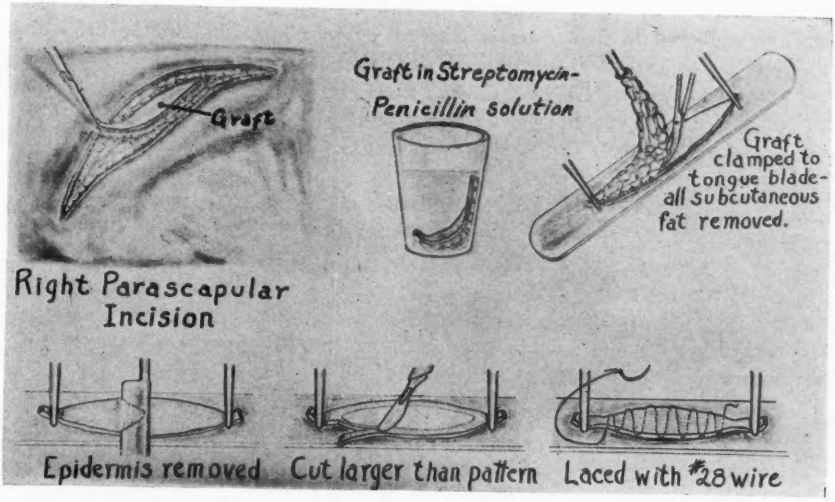

Fig. 9.—Drawings illustrating the technique of preparing a dermal graft for a bronchus.

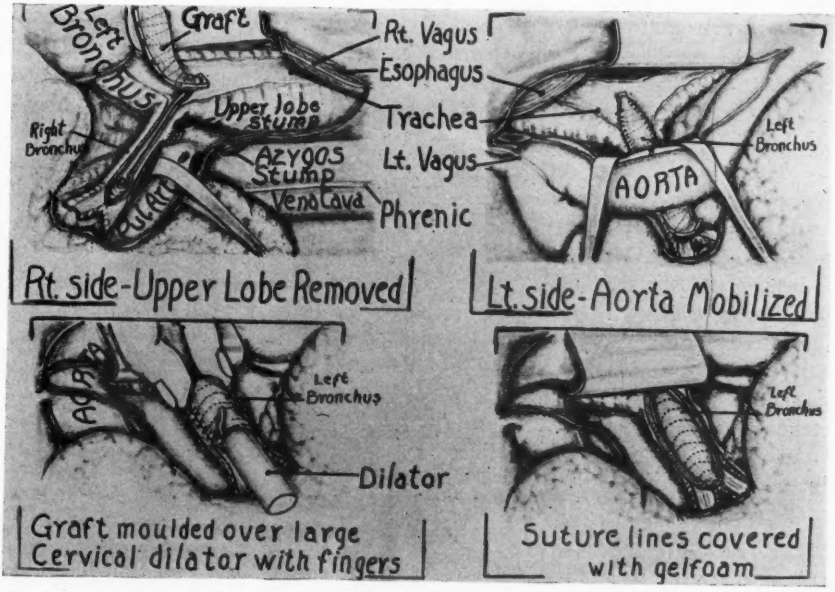

Fig. 10.—Drawings illustrating the exposure of the main bronchus and lower trachea on the right and left sides, and the technique of inlaying dermal grafts.

is laced through the graft for a distance approximating the bronchial incision. Long loops should oppose the narrow portions of the bronchus. The short loops, on the ends, oppose the trachea and bronchi above and below the stenosis.

Redundant skin is left at each end of the graft, by which it is manipulated. The cut surface of the epidermis is applied to face the bronchial lumen. The graft is anchored to the posterior tracheal surface, proximal to the bronchial incision, with a mattress suture. Here the graft lies on the posterior tracheal wall; distal to this the graft is brought into the defect as an inlay, and sutured into place. Every now and then a suture is taken to include a wire loop. The distal end of the graft is fixed in a similar fashion. Thus a small wedge of graft is not made to fit into the angles of the bronchial incision, the most likely point of leakage, or graft slough. Stainless steel, 35 gauge, multistrand, wire sutures on atraumatic needles are used throughout.

Before completing the sutures a large cervical dilator is inserted into the bronchus, and the wire loops and graft are molded over it with the thumb and forefinger (Fig. 10). This produces a round contour, and forms an open bronchial lumen in contrast to a slit. The suture lines are then covered with narrow strips of Gelfoam previously soaked in streptomycin-penicillin solution. These strips should cover only the suture line and not the main surface of the graft. It is hoped that the latter will be a source of blood supply. The intratracheal catheter is then drawn back into the trachea, the lung or lobe inflated and deflated, and the graft tested for air leaks.

Postoperative treatment is the same as for any resection, plus the routine use of antibiotic inhalations and expectorants. Bronchoscopy is done if signs or symptoms of bronchial obstruction occur. It is not warranted for simply "a look at the graft." As a rule, a good airway exists immediately after operation. Obstruction by graulation tissue, loosened mucosa, and organized exudate is likely to occur. When it produces a wheeze it should be removed by bronchoscopic aspiration.

The following four cases are presented only as evidence of the immediate efficacy of dermal bronchial grafts. All the patients are too recently operated upon to warrant any statements regarding the final fate of such grafts, or long-term end results. In each case, by present standards, pneumonectomy was indicated and avoided. So far, each clinical result has been good, and all the patients are well. On the other hand, postoperative bronchoscopic findings have been difficult to appraise and, on the whole, disappointing. Despite apparent full "takes," and early epithelization, the bronchial lumen attained at operation, has not persisted unchanged. This is believed to be the consequence of imperfect technique and inexperience, or poor timing of the procedure in respect to the state of bronchial healing. It could mean, however, that stenosis will eventually recur.

CASE REPORTS

CASE 1.—A. F., woman aged 29 years (Figs. 11 and 12). Minimal pulmonary tuberculosis was discovered three years previously. One year previously, a sudden, acute illness was characterized by a positive sputum and a cavity in the right upper lobe. Right pneumothorax was abandoned after it produced a wheeze and atelectasis of this lobe. Bronchoscopy disclosed ulcerocaseous involvement of the right main bronchial orifice. Good healing of

the bronchial lesion followed treatment with streptomycin. Thereafter, the course was one of intermittent atelectasis with positive sputum, cough, wheeze, and diminished breath sounds, despite a second course of streptomycin. Four months previously, bronchoscopy revealed a healed stenosis of the right bronchus at the carina, with a 3 mm. lumen. Planigrams showed this lesion to involve the whole right bronchus. Sputum culture was still sensitive to streptomycin.

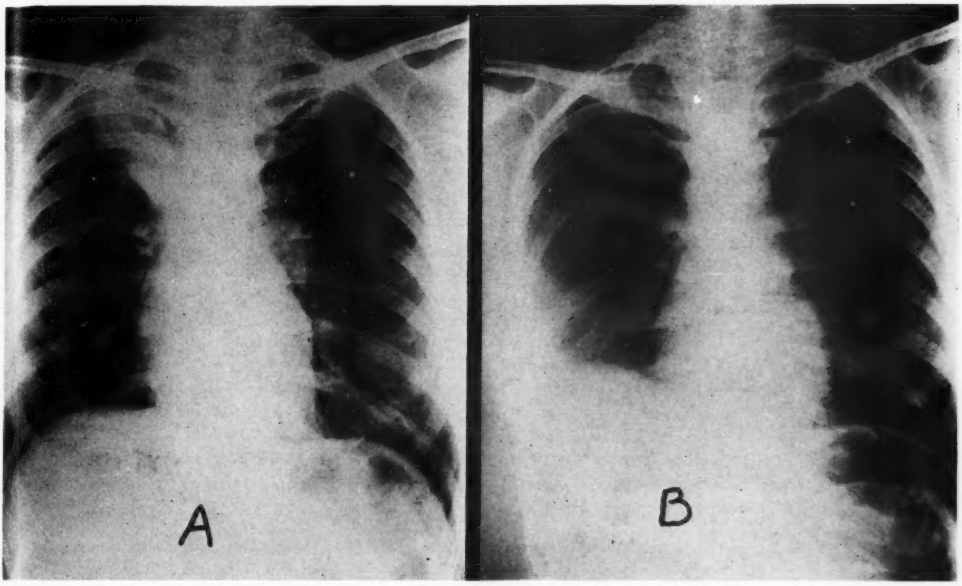

Fig. 11 (Case 1, A. F.).—*A*, Before operation; recently increased partial atelectasis right upper lobe. Sputum positive. *B*, After right upper lobectomy and dermal graft of right main bronchus. Sputum negative.

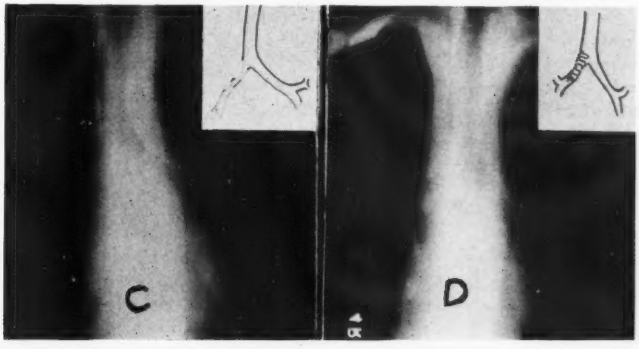

Fig. 12 (Case 1, A. F.).—*C*, Planigram before operation: irregular marked stenosis right bronchus. *D*, Planigram two months after right upper lobectomy and graft of main bronchus. The wire within the graft is poorly reproduced, and the first portion of the main bronchial lumen is in a more anterior plane of focus. Bronchoscopy; graft covered with epithelium, lumen oval and distorted when forced anterior by a straight scope. Bronchoscope with an external diameter of 8 mm. passed into lower lobe without difficulty. Graft possibly too small and not sufficiently rounded.

At operation the middle and lower lobes were blocked in an inflated state. The upper lobe was hard and could not be inflated; its bronchus was scarred, stenotic, and occluded with caseous exudate. The upper lobe was removed. The right main bronchus was markedly narrowed. The posterior surface was easily exposed, narrow, and slightly thickened. Palpable and visible cartilage fragments were few in number and irregularly disposed. The posterior wall was opened from the lower lobe into the trachea. The lower and middle lobe bronchi were normal. Clean mucosa existed on the posterior wall but the anterior bronchial wall was caked with a moist, yellowish-white, fibrinous membrane which was removed, revealing a clean, finely granular, vascular surface. The stenosis was most marked at the carina and opposite the upper lobe. A graft was inserted, as depicted in Figs. 9 and 10. It was not well rounded. A lumen was obtained which admitted an aspirating tip measuring 9 mm. in diameter. Inflation and deflation of the middle and lower lobes was easily accomplished.

The highest postoperative temperature was 100.4° F. on the first and second days. The pulse did not exceed 100 and was normal after the fourth day. Expansion and aeration of the right middle and lower lobes have been present by physical and x-ray examination ever since operation. Because of a wheeze which increased in pitch, bronchoscopy was done on the eighteenth day. The graft was clean, pink, and appeared covered with epithelium. The bronchial lumen was oval in shape and partially obstructed by thin, edematous, filmy tissue, or exudate, hanging like a curtain from the anterior bronchial wall (site of the caked exudate at operation). It was easily removed by aspiration, obtaining a bronchial lumen which admitted a scope (external diameter 8 mm.) into the lower lobe. The wheeze disappeared and later recurred. Bronchoscopy six weeks after operation again showed a small amount of tissue on the anterior wall at a lower level. It was removed by suction. The stump of the upper lobe was healed and clean. The last bronchoscopy, nine weeks after operation, showed complete epithelization of the graft. The most proximal wire loop of the graft bulged into the trachea. Just above the middle lobe orifice, at the distal end of the graft, the bronchial lumen appears as a slit. It accepts a 5 mm. bougie easily. This graft is regarded as too short, too flat, and too narrow near the ends.

CASE 2.—D. K., woman aged 38 years (Figs. 13 and 14). Diagnosis pulmonary tuberculosis made four years previously because of light bilateral apical infiltration. Wheeze and increase in extent of disease one year previously was treated with pneumoperitoneum and streptomycin. The wheeze was relieved but the sputum remained positive. Pneumoperitoneum was abandoned and right pneumothorax started nine months previously. Two months before operation the left upper lobe became atelectatic with the usual signs and symptoms of bronchial obstruction. Bronchoscopy revealed a healed stenosis of the left main bronchus with a 3 mm. lumen at the carina. Within two months an appearance suggesting bronchiectasis of the left upper lobe occurred in the roentgenograms. Planigrams showed narrowing of the whole left bronchus, normal lower lobe, and probable occlusion of the upper lobe. The sputum was positive.

At operation the lower lobe was normal. The upper lobe contained only small patches of air and could be partially inflated from the lower lobe across the hilar portion of the fissure. The apex was hard and irregular; the lingula was solid. The upper lobe bronchus was very small and inseparable from the pulmonary artery. Careful dissection broke into both structures at once. Caseation of the bronchial wall was complete at this point. The artery was temporarily occluded and repaired with a small patch of Gelfoam held in place with overlying arterial sutures taken in the adjacent adventitia. Dissection of the upper lobe bronchus centrally provided solid scar for its suture. The upper lobe was removed. The entire left bronchus was opened. There was a stenosis of varying degree. The lumen at the carina was about 3 mm. The largest lumen elsewhere was 5 mm. The posterior membranous portion was somewhat thickened and narrowed; it was bordered by many fragments of intact cartilage. There was no exudate in the lumen. The mucosa was thin and apparently absent in some areas where the surface was uneven and finely granular. The lower lobe bronchi were normal. A large graft was applied, as depicted in Figs. 9 and 10, and the lower lobe easily expanded.

The patient's temperature rose to 102° F. on the first day. It was 100° F. on the third day and normal thereafter. A pulse of 120 on the first day was normal after the fifth. The lower lobe filled the pleural space by x-ray examination on the first day. Normal breath sounds were audible on the left at all times. The right pneumothorax was maintained.

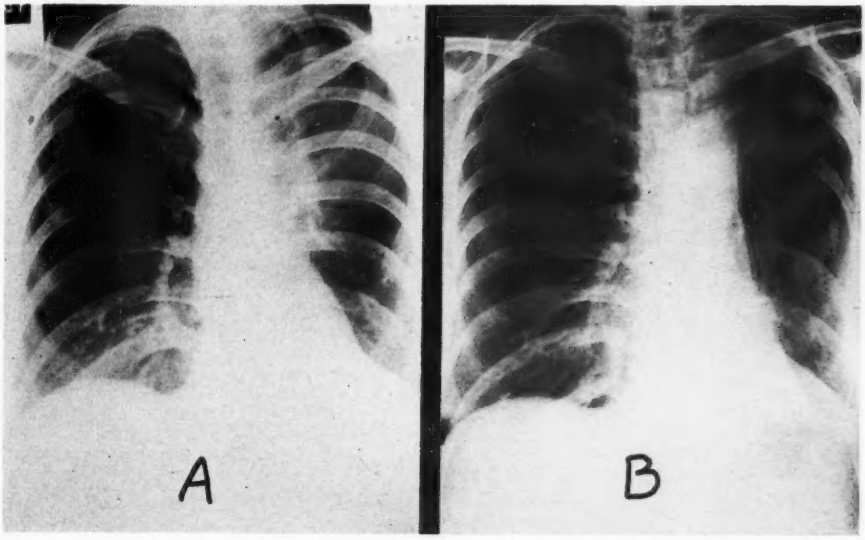

Fig. 13 (Case 2, D. K.).—*A*, Before operation; apical pneumothorax, right, atelectasis left upper lobe. Sputum positive. *B*, After left upper lobectomy and dermal graft to left main bronchus. Sputum negative. Right pneumothorax maintained.

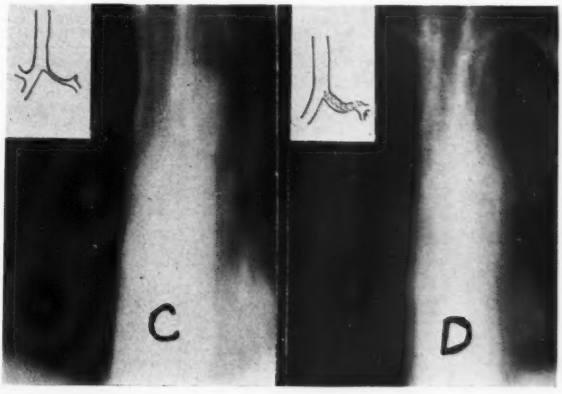

Fig. 14 (Case 2, D. K.).—*C*, Planigram before operation; moderate stenosis whole left bronchus, probable occlusion upper lobe bronchus. *D*, Planigram after operation; good bronchial lumen. Bronchoscopy; scope with an external diameter of 10 mm. passed beyond graft to the lower lobe. Lumen somewhat flattened; graft would be better with a more round contour.

A slight wheeze developed after three weeks and bronchoscopy revealed some fibrinous exudate at the upper angle of the graft which bulged into the tracheal lumen. The graft was clean and pink, except for a few small pale areas. A standard 7 mm. bronchoscope, which has

an external diameter of 9 mm., was passed into the lower lobe. The bronchial lumen was somewhat flattened; it is felt that a more rounded graft would have been better. There has been no further indication for bronchoscopy and the sputum is negative. The right pneumothorax is being discontinued.

CASE 3.—E. Y., woman aged 24 years (Figs. 15 and 16). Left pneumothorax, started for an upper lobe cavity in 1942, was discontinued after two years because of pleural

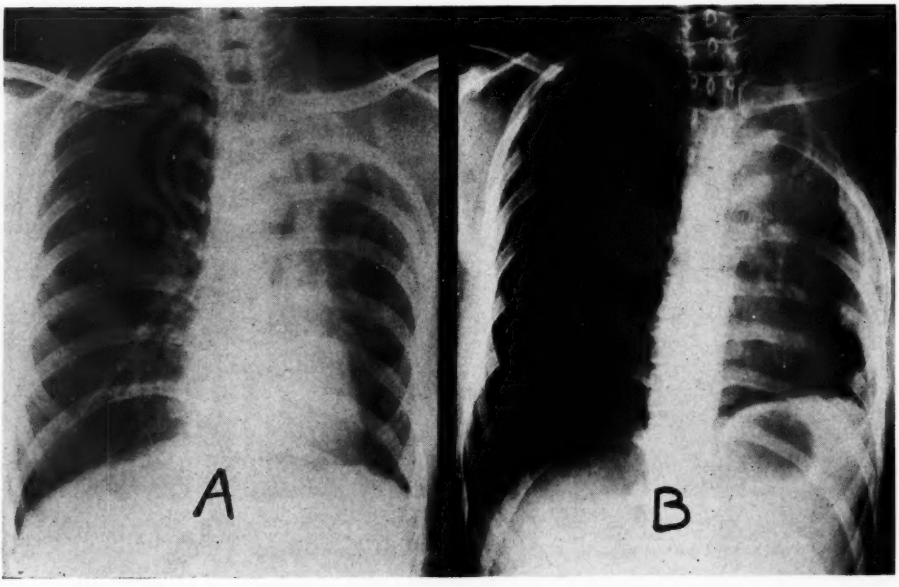

Fig. 15 (Case 3, E. Y.).—*A*, Before operation; normal right lung, incomplete thoracoplasty left. Ventilatory studies much poorer than indicated by roentgenogram. Second stage thoracoplasty avoided because of dyspnea with mild exertion. Sputum positive. *B*, After left upper lobectomy and dermal graft to the distal half of the left bronchus. Paretic left diaphragm from operative trauma is responsible for diminished aeration of the left lower lobe. Despite this, its clinical function is as good, if not better, than before lobectomy. Sputum negative.

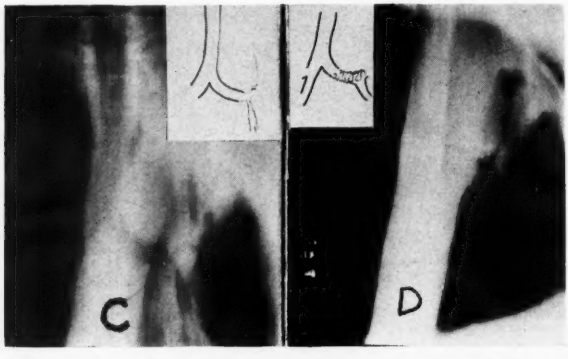

Fig. 16 (Case 3, E. Y.).—*C*, Planigram before operation; stenosis distal portion left main bronchus with marked angulation, and severe stenosis upper lobe bronchus which possibly leads to a slit cavity. Probable functional block of lower lobe in expiration. *D*, Planigram after operation; bronchial lumen good, angulation corrected. Bronchoscopy; scope with an external diameter of 8 mm. passed into lower lobe. Whole bronchial wall is soft and the lumen varies in shape as the bronchus is straightened by the scope. A larger graft would be more satisfactory.

effusion. Two years before operation, reactivation occurred and bronchoscopy disclosed ulcerocaseous involvement of the left upper lobe bronchus. This lesion regressed and flared intermittently for over a year. Healing finally followed a three-month course of streptomycin. Bronchoscopy showed contraction of the left main bronchus but the upper lobe orifice could not be seen. A cavity persisted in the upper lobe and a first stage thoracoplasty was done. Dyspnea was marked in the early postoperative period. After a few months even mild exertion produced some shortness of breath. Ventilatory studies contraindicated further thoracoplasty. The sputum remained positive. Planigrams showed sharp angulation and stenosis of the distal left bronchus, and a thick-walled cavity in the partially collapsed upper lobe. The extremely low respiratory function was out of proportion to the x-ray and clinical findings. It was felt that dyspnea was possibly due to expiratory block of the left lower lobe. Despite the obviously desperate risk, operation was undertaken with the hope of excising the upper lobe and restoring the lower lobe to better function by correction of the bronchial deformity.

At operation the hard, airless upper lobe was freed in the extrapleural plane. The fissure was fused. The lower lobe contained no palpable induration; it did not deflate except with manual pressure. The upper lobe bronchus was represented by dense scar inseparable from the pulmonary artery. A portion of the bronchial wall was excised and left adherent to the artery. The upper lobe bronchus contained caseous exudate. The upper lobe was removed. The whole main bronchus was scarred. Cartilages were absent in the distal portion, opposite the upper lobe stump, and here the bronchus was soft and collapsible. The lumen measured about 4 mm. The bronchus made a sharp angle at this point and was lined with thin mucosa which appeared normal on the posterior wall. The lower lobe bronchi were normal. The distal half of the main bronchus was reconstructed with a dermal graft. Following this, the lower lobe could be inflated at will. The left phrenic nerve was inadvertently crushed with forceps during closure of the mediastinal pleura.

On the first postoperative day the temperature was 102° F. and pulse 140. On the third day the temperature was 100° F. and pulse 110. The left lower lobe was well expanded but aerated poorly. Fluoroscopy revealed elevation and paralysis of the left diaphragm. On the sixth day breath sounds were more diminished and bronchoscopy disclosed partial bronchial obstruction by a flap of loosened mucosa just above the graft. The graft was intact and pink in color. However, the bronchial wall was rather soft and the lumen flattened. It was possible to pass a scope, with an external diameter of 8 mm., beyond the graft. Following bronchoscopy, aeration of the left lower lobe improved and three weeks later the chart curves were normal. Since then there has been no indication for bronchoscopy but the left diaphragm has not recovered its function.

CASE 4.—R. C., woman aged 26 years (Figs. 17 and 18). Onset two years previously with acute laryngitis and a dense left upper lobe containing a cavity. The larynx improved and bronchoscopy a year later showed active caseous involvement and stenosis of the left bronchus at the carina. Three months later, after streptomycin, this was healed and the lumen measured 2 to 3 mm. The sputum became negative. Atelectasis of the left upper lobe was intermittent until one month before operation, when it increased and persisted. There was increased cough and occasionally purulent sputum which was negative. Examination revealed a wheeze, and diminished to absent breath sounds over the whole left chest. Planigrams showed stenosis of the whole left main bronchus and apparent occlusion of the upper lobe bronchus.

At operation the lower lobe was hyperexpanded. It contained no palpable nodules or induration. The upper lobe was a small, firmly puckered structure drawn down toward the hilum. It contained many small, hard, palpable nodules. The secondary bronchi of the upper lobe were all dilated. The upper lobe bronchus itself was short, contracted and hard. The lumen was completely occluded by healed scar. The upper lobe was removed. The main bronchus was markedly contracted. The posterior surface was easily exposed. The membranous portion was narrow and only slightly thickened. Irregular fragments of cartilage were visible and palpable at the margins. The lumen was lined with thin mucosa and exhibited numerous pits and linear depressions. There was no exudate. The lower lobe

bronchus and dorsal lobe orifice were normal. The stenosis was most marked at the carina and just proximal to the upper lobe stump. A dermal inlay graft was applied, as depicted in Figs. 9 and 10. It was approximately ¾ inch wide and 2¼ inches long. The aortic arch was mobilized and retracted to expose the trachea and central portion of the bronchus for

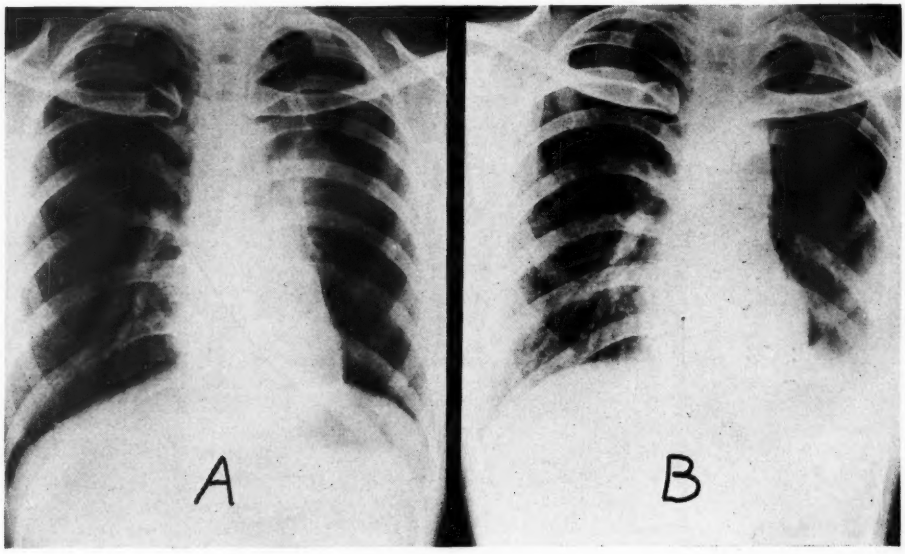

Fig. 17 (Case 4, R. C.).—*A*, Before operation; small contracted, partly atelectatic, left upper lobe. Sputum negative. Recent increase in the size of the upper lobe density plus increased cough and wheeze occurred. Diminished to absent breath sounds over whole left chest. *B*, After left upper lobectomy and a dermal graft to the whole main bronchus.

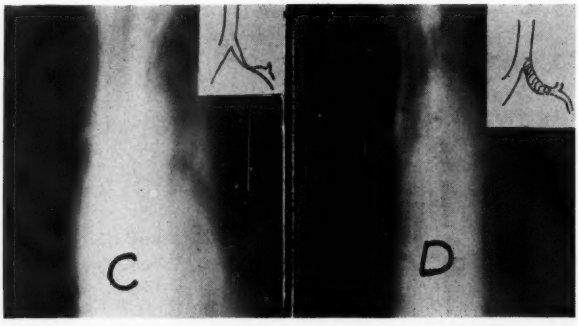

Fig. 18 (Case 4, R. C.).—*C*, Planigram before operation; stenosis of the left main bronchus, occlusion of the upper lobe bronchus. *D*, After operation; good bronchial lumen; well-rounded graft. Graft epithelized within five weeks: good, open, round bronchial lumen beyond the carina. Possibly recurring stenosis at the carina.

suture. Retraction of the aorta caused considerable stretch of the recurrent laryngeal nerve. After the graft was applied, the lower lobe inflated and deflated easily.

The highest postoperative temperature was 100.1° F. and pulse 104 on the second day. Both were normal after the fourth day. The lower lobe was completely expanded on the

first day. The drainage tube and suction were discontinued after forty-eight hours. Since operation, normal breath sounds have been audible over the left chest. Mild dysphagia was present for two weeks. The left vocal cord was still paralyzed five weeks after operation.

At bronchoscopy the graft appeared covered with epithelium. The upper end of the wire within the graft projected from the posterior tracheal wall. The lumen at the carina was about 5 mm. This narrowing was due to a crescent-shaped partition of tissue which was displaced with the tip of the scope. A standard 7 by 40 scope was passed to the lower lobe branches. Beyond the carina the bronchial lumen was clean and large.

This was a big, well-rounded graft. The recurrent narrowing at the carina was disappointing in view of the excellent state of the graft and the bronchial lumen beyond it.

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8. May, H., and Spann, R. G.: Cutis Grafts for Repair of Incisional and Recurrent Hernias, S. Clin. North America, **28**: 517, 1948.

DISCUSSION

DR. E. J. O'BRIEN, Detroit.—When I was in Hawaii in January, I was so impressed with Dr. Gebauer's results with dermal graft that I asked him to present his work at this meeting. With his inherent modesty he was reluctant to report so small a series of successful operations, but I persuaded him to come and present his work as a preliminary report.

Dogs are very difficult to obtain in Hawaii. I, therefore, promised him I would try some cartilaginous transplants, portions of bronchi, tracheas, etc.

Dr. Jackson, who is one of our residents, has done much of this work. With your kind permission I should like to have him tell you what we have found to date.

I want to make it clear that this work was done at the instigation of Dr. Gebauer, and as such is really a collaboration and not a discussion.

DR. T. L. JACKSON, Detroit.—We have been interested in the healing of the trachea and bronchus for some time. At present we have ten dogs in which we have used fresh bronchus and tracheal grafts to close defects. These sections of the trachea have been taken from other dogs. The grafts have been prepared by removing the mucosa and serosal surface and some of them have been prepared in solutions and refrigerated for as long as three weeks. To repair the bronchus we have used a large cylinder of trachea, removing the membranous portion completely. A portion of the main bronchus was resected and this section of trachea placed around both ends of the bronchus so that the continuity of the main bronchus was re-established by a tube of trachea which is completely surrounded by cartilage and, for that reason, fairly rigid. We have observed the dogs for two and one-half months. At present there is evidence that the mucosa is covering the grafts completely, the dogs are well, and we see no evidence of a significant stenosis. However, it will be necessary to keep the dogs eight months to a year, sacrifice them periodically, and at that time we will be able to tell whether the grafts fulfill all the conditions Dr. Gebauer says must be fulfilled. It is our opinion, however, that the grafts merely act as a framework for the mucosa to grow over and for possible regeneration of the other structures of the trachea and bronchial wall.

DR. EDWARD J. O'BRIEN, Detroit.—Thank you for allowing Dr. Jackson to discuss this paper, but this is such an integral part of Dr. Gebauer's talk and it was all at his instigation; none of the ideas were ours, they were all Dr. Gebauer's. I thought it best to have Dr. Jackson talk first.

ADDENDUM AND FOLLOW-UP, NOV. 30, 1949

The reasons for the disparity between the particularly good clinical results, and the sometimes puzzling bronchoscopic findings, have become apparent since the submission of the preceding paper. They are depicted in Fig. 19, and were elaborated in a report already published.*

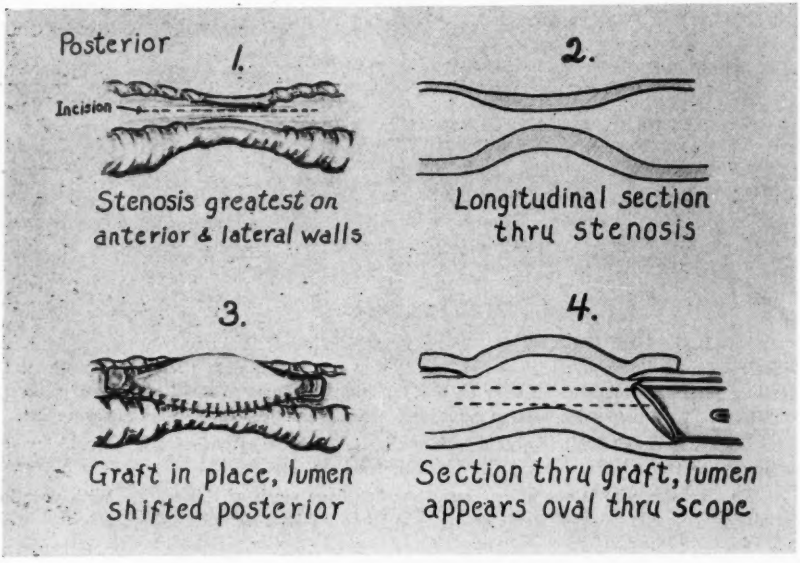


Fig. 19.—Drawing demonstrating the usual transposition of the bronchial lumen by a posterior dermal graft, and the consequent bronchoscopic appearance.

In addition, it seems that a bronchial passage does not have to be normal in caliber and contour to be physiologically adequate. Evidently there is a crucial point in the degree of bronchial stenosis or deformity in each individual case. Until a stenosis reaches this point, lung function is practically normal and there are few significant clinical symptoms. On the other hand, once the crucial degree of stenosis is obtained—whether by fibrous contracture, edema, inflammation, or dried secretions—cough, wheeze, x-ray evidence of expiratory block, or intermittent atelectasis occur, and a gradual process of lung destruction is initiated.

It is quite likely that dermal bronchial grafts will restore stenosed bronchi to normal shapes and dimensions only occasionally. The incidence of such results depends on many factors. Of these, the experience of the operator is highly important.

*Hawaii M. J. 8: 413-418, 1949.

The following is a report on the status of each of the patients reported in the preceding paper a year or more after operation.

CASE 1.—A. F. (Fig. 20). The upper, extreme end of the wire within the graft was cut and removed from the posterior tracheal wall through a bronchoscope. The bronchus, six months after operation, was clean and glistening. The lumen was oval and small at the distal end of the graft. A 6 mm. dilator was easily passed. The patient was discharged eight months after operation, sputum negative, free of symptoms, and the chest examination was normal. One year after operation the patient is working part time; there are no

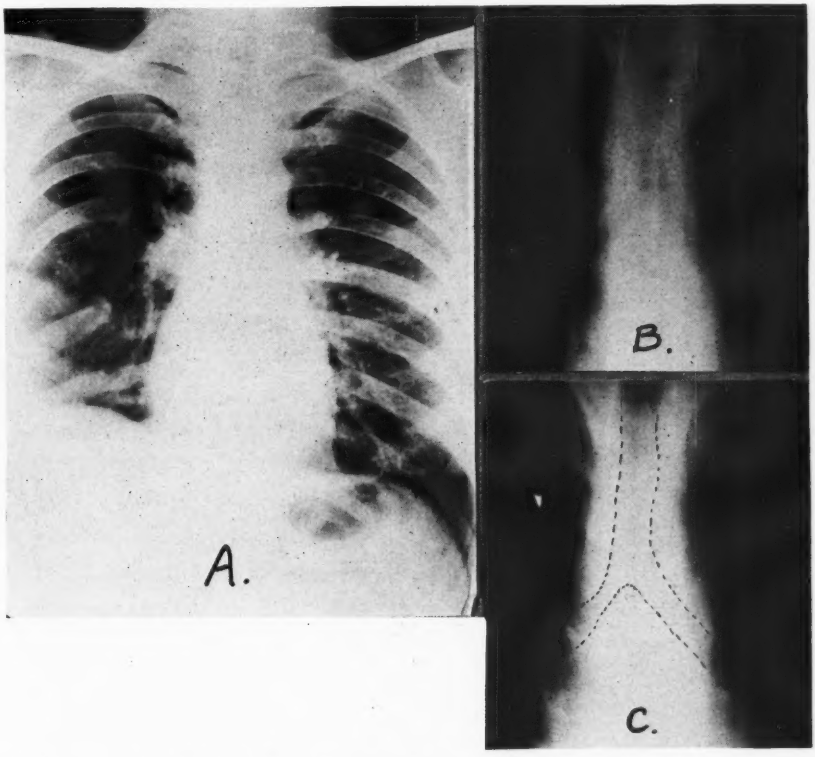


Fig. 20 (Case 1, A. F.).—*A*, Chest film one year postoperative. *B*, Unmarked planigram of trachea and bronchi eight months after operation. *C*, Same, marked.

symptoms. She feels that she can breathe much deeper and easier than before operation. Bronchograms show the right main bronchus to have a caliber about one-half that of the left main bronchus. The grafted bronchus is evidently physiologically adequate, although far from anatomically perfect.

CASE 2.—D. K. (Fig. 21). There were never any significant bronchial symptoms in the postoperative period. Good breath sounds were always audible on the left. A standard 7 by 40 bronchoscope could be passed through a clean, smooth, grafted bronchus and the lower lobe branches inspected. This was difficult because of stiffness of the bronchus and an exaggerated upward curve (Fig. 21, *B*). The patient professed a marked improvement in breathing capacity. Undoubtedly some of this was due to expansion of the small right pneumothorax. Eight months after operation a modified thoracoplasty was done over the expanded

left lower lobe because a light nodular infiltration appeared in its apex and the sputum became positive (Fig. 21, *A*). Cultures were still sensitive to streptomycin and a three-month, 90 Gm. course was administered. The patient had no difficulty with the one-stage thoracoplasty. She was discharged one year after bronchial graft, symptom free, and sputum negative. Physical examination discloses no difference in good bilateral breath sounds. This graft is considered anatomically, as well as physiologically, adequate.

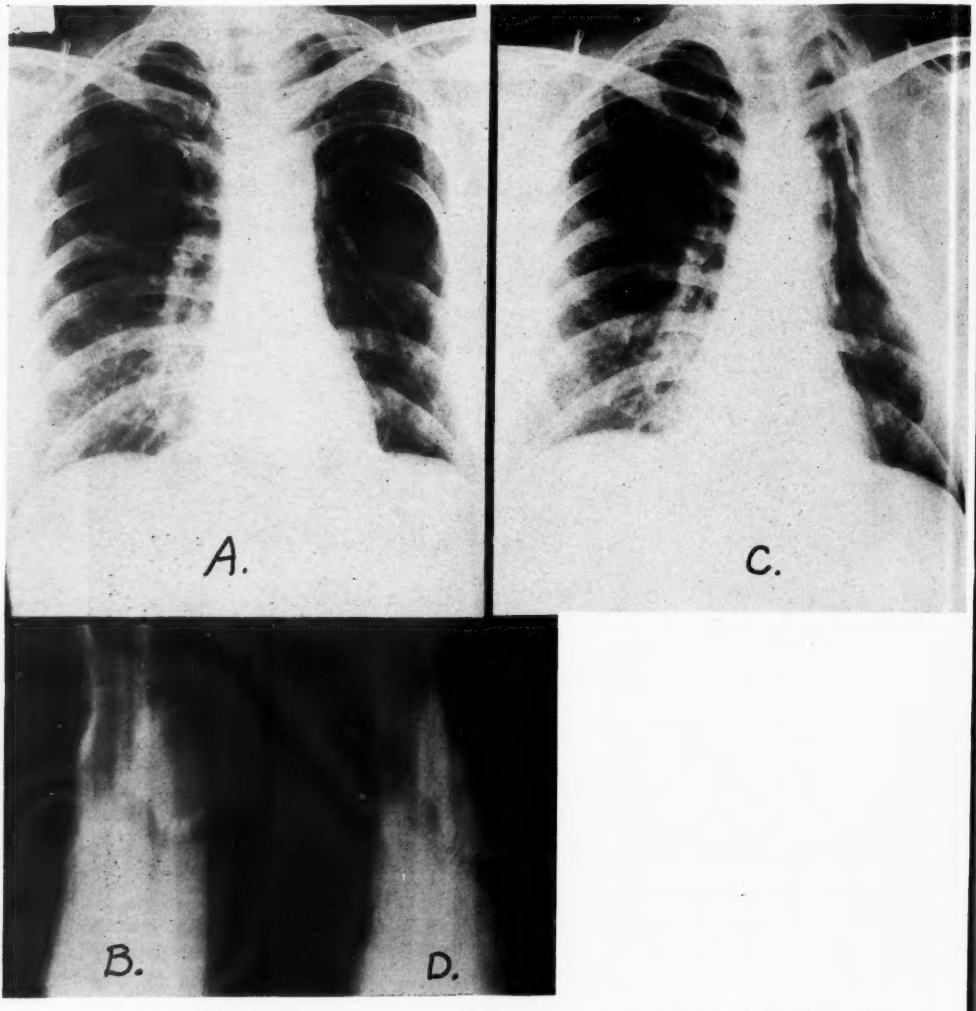


Fig. 21 (Case 2, D. K.).—*A*, Chest film eight months postoperatively, light nodular infiltration expanded apex of left lower lobe. *B*, Planigram of trachea and bronchi at that time. Sputum positive. *C*, Chest film one year after bronchial graft and four months after thoracoplasty. *D*, Planigram same time.

CASE 3.—E. Y. (Fig. 22). Considerable respiratory improvement occurred when the left diaphragm began to function five months after operation. Ventilatory studies indicated a 300 c.c. increase in vital capacity compared to preoperative determinations. They also

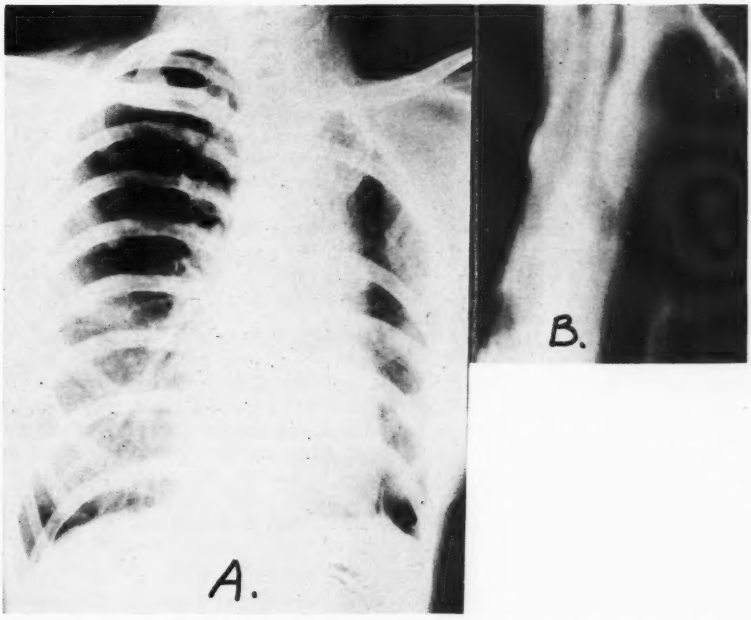


Fig. 22 (Case 3, E. Y.).—*A*, Chest film one year after bronchial graft, left diaphragm has descended. Note low, flat diaphragm, typical of emphysema. *B*, Planigram of trachea and bronchi same time.

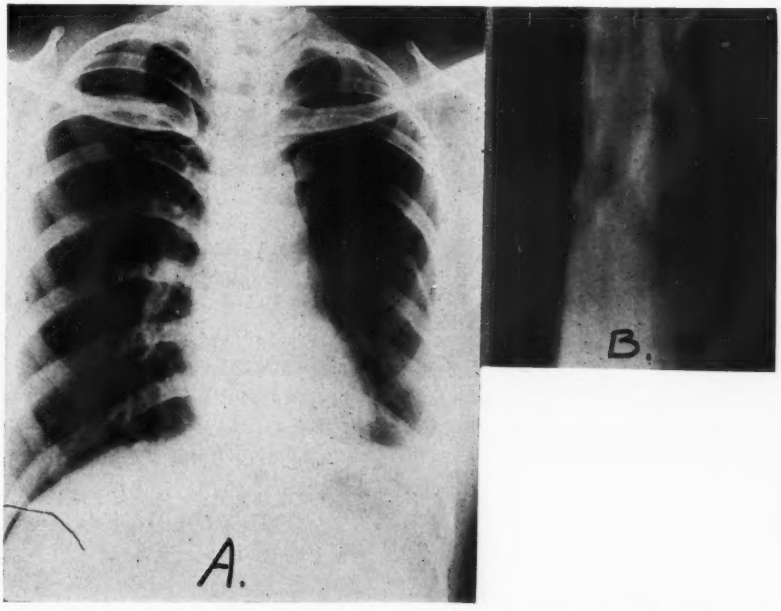


Fig. 23 (Case 4, R. C.).—*A*, Chest film one year after bronchial graft. *B*, Planigram of trachea and bronchi same time.

support the clinical impression of severe emphysema, probably present a long time before the first-stage thoracoplasty. She still has dyspnea on exertion. Eight months after operation she was transferred to an ambulant ward preparatory to discharge. A bronchoscope with a 6 mm. lumen could be passed to the branches of the lower lobe without difficulty, but the bronchial wall is rather soft in the region of the graft; otherwise nothing can be observed to distinguish the graft from the remainder of the bronchus. On the ambulant ward the patient had some difficulty with a long walk to meals, and a severe secondary anemia occurred. This was corrected and she is about to be discharged from the hospital. All sputum examinations have been negative since operation.

In summary, it is felt that thoracoplasty was contraindicated in the first place, because of an unsuspected emphysema. Lobectomy has probably arrested or cured her tuberculosis, but has not materially altered her prognosis. The bronchial graft has undoubtedly improved the respiratory function by permitting better use of the left lower lobe.

CASE 4.—R. C. (Fig. 23). Subsequent bronchoscopies revealed a good bronchial lumen over 8 mm. in diameter and apparently lined with clean epithelium. The early pessimism was unwarranted. The protruding wire was cut and removed from the lower trachea. Since then no wire has ever been visualized and an excellent bronchial lumen is present. This patient feels a marked improvement in breathing capacity. As before operation, sputum examinations have remained negative. She was discharged five months after operation. She had no symptoms and normal breath sounds on both sides. The preoperative hoarseness has been increased by the addition of a persistent left vocal cord paralysis to a scarred larynx. One year after operation she is doing all her own housework and is symptom free.

EVALUATION OF EXTRAPLEURAL PNEUMONOLYSIS AND PARAFFIN PLOMBAGE FOR CHRONIC PULMONARY DISEASE

H. Ryerson Decker, M.D.
Pittsburgh, Pa.

THE operation of paraffin plombage following extrapleural pneumonolysis for collapse treatment of pulmonary tuberculosis was proposed by Baer and used first under his direction in 1913, when other materials aimed to stabilize and maintain extrapleural collapse, such as fat, muscles, gauze, had proved unsatisfactory. In the years following it had considerable vogue in Europe. In this country, however, the procedure has never had popularity nor widespread use, judging by the comparatively few reports in the literature. The purpose of this paper is threefold: (1) to review briefly the indications, limitations, and technique of the operation; (2) to report a small series of my own cases, twenty in number; seventeen for pulmonary tuberculosis and three for nontuberculous pulmonary suppuration; (3) to evaluate results as recorded in the literature.

Plombage can be used successfully to accomplish the collapse of a localized tuberculous lesion, and particularly one with a coexistent cavitation. The ideal location is the apex of the lung. The distinct appeal of the operation lies in the fact that it is not ordinarily a hazardous surgical procedure, resulting in mortality, and therefore, may be undertaken in cases of poor surgical risk, either on account of tuberculosis or systemic disease. Furthermore, because of its selectivity, it spares good lung and conserves vital capacity. If plombage fails to accomplish its collapse objective, thoracoplasty may still be utilized.

Plombage can be either an elective primary operation or one supplementary to other collapse procedure. It is chosen in preference to other methods of collapse therapy such as intrapleural pneumonolysis, phrenic crush, or thoracoplasty, when they have been judged either not feasible, not servicable, or too hazardous. In the poor risk group, it may be undertaken to improve the condition of the patient in preparation for a later thoracoplasty. As secondary operation, plombage is used when other methods have been tried and have failed to close cavitation.

Most cases in which plombage is to be used have far-advanced bilateral tuberculosis and demonstrable single or multiple cavities. Experience has shown that the ideal group has a unilateral lesion extending not lower than the second intercostal space, and a cavity not more than 2 cm. in diameter. The scope, however, is much broader and includes the following groups of cases:

1. Unilateral lesion which extends not lower than the second intercostal space
2. Unilateral lesion with low vital capacity

Read (by title) at the Twenty-eighth Annual Meeting of The American Association for Thoracic Surgery, Quebec, Canada, May 31, June 1, 2, 1948.

3. Bilateral lesion with contralateral lung inactive
4. Bilateral lesion with both apices active in good risk cases
5. Bilateral lesion, active tuberculosis in opposite lung

CONTRAINDICATIONS

Plombage will prove disappointing in the following groups:

1. Where the patients are seriously ill with low resistance
2. Where it is undertaken as a matter of last resort
3. Where the disease has extended to the middle or lower lobes
4. Where the disease is acute
5. Where cavities are extremely rigid or more than 4 cm. in diameter.

OPERATIVE TECHNIQUE

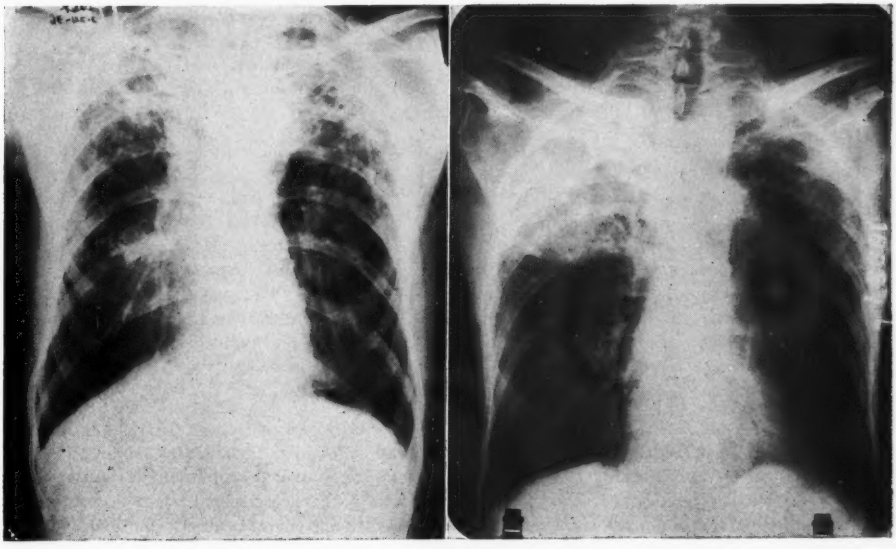
The operative technique is not complex. For apical lesions posterior exposure is preferable to anterior approach, chiefly on account of the better skeletal muscle support. With a paravertebral incision centering just above the spine of the scapula a section of the third or fourth rib when removed will give good access to the apex of the lung. Once the line of cleavage between the parietal pleura and the endothoracic fascia is established, careful gentle dissection with the finger, or a gauze sponge in a holder will mobilize the apex of the upper lobe satisfactorily. Frequently several resistant fascial bands will require sharp division and ligation between clamps. The procedure can be almost bloodless. At times it may be impossible to secure a safe line of cleavage and the operation will have to be abandoned. This happened in one of my cases. At other times difficulty will be found in separating the mediastinal pleura, and it may be the part of wisdom to desist to avoid tearing into the lung or great vessels. Separation should be sufficient to secure good lung relaxation, and apparently to prevent the cavity from being pinned against the vertebral column. Contrariwise separation should not be so extensive that it does not afford a proper supporting bed for the paraffin. Seldom should the separation extend below the level of the fourth rib. There is always a tendency for a cavity to sink downward and inward and escape collapse. Gentle handling is likely to minimize bleeding and subsequent serous exudation, and to prevent perforation of the lung or pleura. Paraffin should act as a passive agent. Pressure effect is to be avoided, unless in the case of scirrhous cavities. Therefore, large packs in excess of 500 Gm. are contraindicated. Usually a pack of 200 to 300 Gm. will be sufficient and will be well tolerated. The actual amount used will depend considerably on the size of the cavity, the resistance of the lung, and the character and extent of the disease. After paraffin with a melting point of 52° F. or more is placed in the prepared cavity, muscle planes should be accurately closed to help prevent any extrusion of the pack. Careful asepsis pays dividends, but does not prevent infection of the field from a pulmonary or pleural focus. Added safety comes now in the use of antibiotics, as when penicillin and streptomycin are instilled into the wound, and administered intramuscularly before and after operation. Should infection develop, early removal of the pack is indicated with appropriate treatment such as Dakinization of the infected cavity or injection of the antibiotics locally.

The choice of anesthesia depends upon the individual case: taking into consideration the general physical condition, the gravity of the pulmonary lesion, and mental reaction. My own practice has been to use local Novocain anesthesia and to supplement this as indicated with small amounts of intravenous pentothal or with a basic dose of Avertin. In recent years, however, I have practically discarded the use of Avertin for all surgery. It is my conviction that at the close of any operation for pulmonary disease, or soon thereafter, it is important for the patient to cough and take deep breaths. Local anesthesia allows this.

Postoperative course is usually uneventful. Fever of several degrees for several days is to be expected. Rest in bed is advisable for a period of four or five weeks, until a foreign

body reaction has formed a connective tissue capsule and adequate septum or shelf beneath the plug and above the collapsed lung to prevent migration of the paraffin. Cavities will diminish in size quickly or gradually to the point of obliteration, depending upon the speed of cicatrization in the individual case.

My own group of 17 tuberculous patients were largely war veterans in an age group of the fifth and sixth decades, and known to have had tuberculosis for six months to eleven years. All, with one exception, had far-advanced bilateral disease, and all had cavitation. The disease was limited to upper lobes in 13; 4 cases had scattered involvement in other lobes. In 1 case there was a unilateral basilar lesion. The sputum was laden with tubercle bacilli. In only 4 cases was the operation a primary procedure. Eleven had had a previous ineffectual artificial pneumothorax; 2 of these also a phrenic crush. Two had had only a previous phrenic crush. In almost every instance a thoracoplasty was considered, but decided against either on account of the patient's condition as contraindicated at the time or because the patient refused to have it. Two patients had plombage as a last resort, and both did badly. Cavities were unilateral in 8 cases, bilateral in 9, and ranged in size from 1½ to 4 cm. Bilateral operations were done in 2 cases, were proposed, but refused in 3 others. In 1 case the operation was attempted but not completed, because a cleavage line of the pleura could not be obtained.



A. *B.*

Fig. 1 (Case 1).—R. D. J., aged 57 years. Refused thoracoplasty; 3½ cm. heavy-walled cavity right apex practically closed by plombage. Sputum converted. *A*, Before plombage, *B*, four months later. Bucky exposure.

CASE REPORTS

CASE 1.—**R. D. J.** Clerk. Age, 57 years. Symptoms for one and one-half years. Admitted Veterans Hospital, Aspinwall, February, 1936. Bilateral upper lobe tuberculosis to fourth spaces. Cavity, right lung, 3.5 cm.; left lung, 2 cm. Sputum positive. Refused thoracoplasty. Plombage, June, 1936. Novocain anesthesia; 350 Gm. pack. Two-inch section third rib. In August, 1936, cavity closed. Sputum negative. Plombage was planned for left apex. Patient went A. W. O. L. Has not been traced.

CASE 2.—P. R. Salesman. Age, 41 years. Symptoms for two years. Admitted Aspinwall, 1935. Bilateral lesion, infiltration both upper lobes with small areas of disease

in the lower lobes. 4 cm. cavity, left upper lobe. Sputum positive. Artificial pneumothorax begun left side, 1935; phrenic crush, February, 1936. Some improvement in the lung. No effect on cavity. Plombage, September, 1936. Novocain Avertin anesthesia. Two-inch section third rib. 350 Gm. pack. November, 1936, roentgenogram showed cavity closed. Sputum negative. January, 1938, transferred to Sunmount. Discharged April, 1942, maximum benefit. No active tuberculosis. Cavity closed by plombage. Sputum negative on guinea pig inoculation. Died in 1943, whether from tuberculosis is not known.

CASE 3.—J. T. C. Age, 52 years. Restaurant operator. Symptoms two years. Admitted Veterans Hospital, Aspinwall, 1935. Bilateral upper lobe tuberculosis with scattered areas in all lobes. 4 cm. cavity, left upper lobe. General condition poor. Sputum positive. Artificial pneumothorax right side; secured 50 per cent collapse; left side, 25 per cent collapse. No effect on cavities. Plombage March, 1937. Novocain anesthesia. Two-inch section third rib removed; 300 Gm. pack. Roentgenogram showed April, 1937, cavity apparently collapsed. Sputum remained positive. Died May, 1938, of progressive tuberculosis.

CASE 4.—E. T. Negro. Mill worker. Age, 42 years. Symptoms since January, 1935. Admitted to Aspinwall October, 1935. Spotty infiltration all lobes bilaterally; 7 cm. cavity in left upper lobe and 2¼ cm. cavity in right upper lobe. Sputum positive. Artificial pneumothorax instituted on right side. Discontinued in five months. Plombage, right, September, 1937. Novocain anesthesia. Small sections third and fourth ribs; 250 Gm. pack. Refused operation for left-sided cavity. Roentgenogram September, 1938, showed cavity in right lung closed. Sputum still positive. Generalized extension of tuberculosis. Died December, 1938, with left-sided pyopneumothorax.

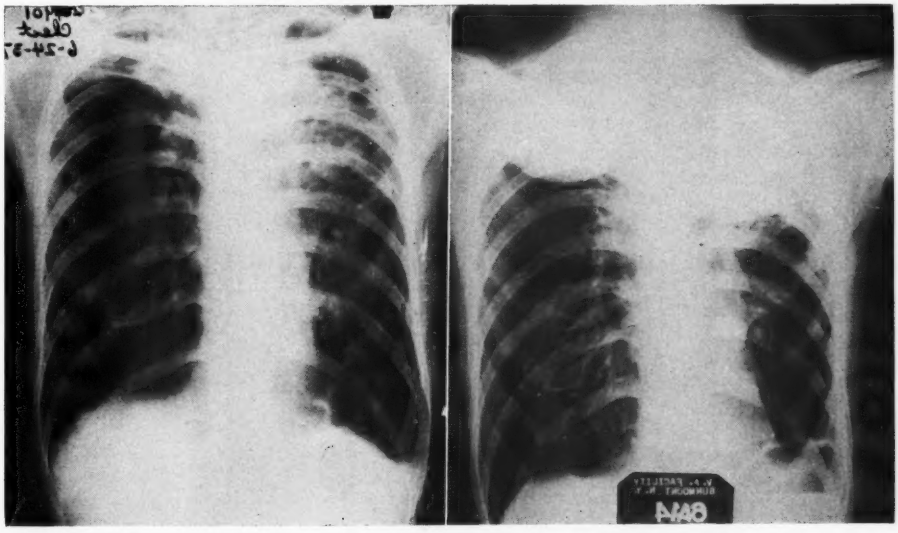
CASE 5.—M. H. Repairman. Age, 42 years. Onset of tuberculosis, 1930. Treated Castle Point 1932 to 1936. Admitted to Aspinwall December, 1936. General condition good. Bilateral tuberculosis, infiltration of right upper lobe to fifth space with 3 cm. cavity; left upper lobe to fourth space. Sputum positive. Artificial pneumothorax begun on right side. Discontinued December, 1937. Plombage right apex August, 1937. Novocain anesthesia. Two-inch resection of third rib; 500 Gm. pack. General clinical improvement. Twenty-pound gain in weight. Sputum converted to plus zero. October, 1937, roentgenogram showed cavity closed, no evidence of active disease in either lung, pleural thickening, right costophrenic sinus obliterated; upper one-third left lung, well-organized fibroid deposit. Admitted Sunmount, March, 1939. No active disease in either lung. Sputum negative. Has not been traced since discharge with maximal hospital benefit.

CASE 6.—M. H. C. Machinist. Age, 37 years. Onset of tuberculosis, 1931. Admitted Aspinwall, August, 1931, and subsequently three times. August, 1937, bilateral tuberculosis involving upper two-thirds of left lung, and apex of right lung where there was a 3 cm. cavity; a smaller cavity 1½ cm. in left apex. Sputum positive. Artificial pneumothorax instituted on left side proved inefficient. General condition poor, emaciated, and toxic, and not suited for thoracoplasty. Plombage January, 1938. Novocain and Avertin anesthesia. Two-inch section of fourth rib; 500 Gm. pack. Roentgenogram April, 1938. Cavity right lung closed. Some improvement in general condition. May, 1938, plombage for left apical cavity. Novocain and Avertin anesthesia. Two inches fourth rib; 500 Gm. pack. Condition remained static. Transferred to Sunmount, August, 1938. Roentgenogram showed no cavitation in either apex. Adhesive pleuritis small areas of well-organized fibrosis in left lung. Sputum negative. September, 1938, began to spit up small bits of paraffin. November, 1938, paraffin pack removed by Dr. Welles. Was discharged from Sunmount as having maximal hospital benefit, 1940. Untraced since then.

CASE 7.—J. H. M. Salesman. Age, 44 years. Onset of tuberculosis, 1927. Artificial pneumothorax had been tried and failed in hospital, Hopemont, W. Va. Admitted to Aspinwall, January, 1937. Bilateral pulmonary tuberculosis, upper one-third left upper lobe with 2 cm. cavity, upper one-fourth right upper lobe 1½ cm. cavity. Sputum positive. Refused

thoracoplasty. Plombage, December, 1937. Novocain anesthesia. Two-inch section third rib right; 500 Gm. pack. March, 1938, cavity closed apex. Refused operation on left side. Discharged July, 1938. Sputum plus zero. Readmitted July, 1939. Cavity 3½ cm. upper lobe below paraffin pack. Right upper lobe 3 cm. cavity. Sputum positive. Transferred to Hopemont. Died December, 1940, of progressive tuberculosis.

CASE 8.—R. W. H. Age, 40 years. Laborer. Symptoms for two years. Admitted to Veterans Hospital, Aspinwall, September, 1937. Tuberculosis bilateral involving upper two-fifths of left lung and upper one-half of the right lung. Bilateral cavitation 3.5 cm. Artificial pneumothorax instituted on right side. Secured only 25 per cent collapse. Plombage, right, January, 1938. Novocain anesthesia. Two-inch section third rib; 500 Gm. pack. Sputum converted to plus zero. Following operation developed recurrent hemoptysis. April, 1938, phrenic crush. Did not stop hemoptysis. Roentgenogram showed no diminution of size of right cavity. Progressive extension of disease in both lungs. Death May, 1938.



A. *B.*

Fig. 2 (Case 6).—M. H. C., aged 44 years. Bilateral plombage. Marked clinical improvement. Sputum converted. *A*, Before plombage. *B*, Eight months after left and four months after right plombage.

CASE 9.—S. M. Age, 39 years. Negro porter. Tuberculosis since 1934. Admitted Aspinwall, September, 1937. Bilateral pulmonary tuberculosis involving both upper lobes as far as the second interspace. On left side a 3½ cm. cavity, on right 1 cm. Sputum positive. General condition good. Artificial pneumothorax instituted on left side. Partial collapse, but cavity not affected. Plombage, May, 1938. Novocain Avertin anesthesia. Section 1½ inches right fourth rib. Roentgenogram September, showed cavity 1 cm. in diameter. February, 1939, no cavity seen. Sputum negative. Forty pounds gain in weight. Artificial pneumothorax continued on left side. Discharged May, 1939, with maximum hospital benefit to return to outpatient department for continuation of artificial pneumothorax. Readmitted June, 1940. Spitting up paraffin. Both upper lobes showed marked fibrosis, especially about the right apical pack and a small fibrotic area in right apex, indicating closed cavity. Sputum negative. August, 1941, developed a spontaneous collapse of right lung from which he made a good recovery, but a spread of the disease in the right upper lobe was noted. Later progressive extension in both lungs. Apparently a new cavity developed in the base of the left upper lobe. Death in April, 1942.

CASE 10.—H. O. H. Age, 48 years. Clerk. Onset of tuberculosis, 1934. Admitted Aspinwall, April, 1938. Bilateral tuberculosis, infiltration of right upper lobe with 1½ cm. cavity; fibrosis of left apex. Sputum plus zero. Clinically an associated bronchitis. Refused thoracoplasty. Plombage, October, 1939. Novocain anesthesia. Two-inch section third rib; 150 Gm. pack. Pleura was accidentally opened, followed by a marked collapse of the lung and dyspnea. Relieved by aspiration of 1,000 c.c. air. April, 1940, roentgenogram showed cavity to be closed. Sputum negative. Readmitted January, 1943, on account of asthma and dyspnea. Roentgenogram showed no evidence of active tuberculosis. Sputum negative. Readmitted October, 1947, on account of asthma. No evidence of an active tuberculosis. Sputum negative. April, 1948, only symptoms due to asthma and chronic bronchitis.

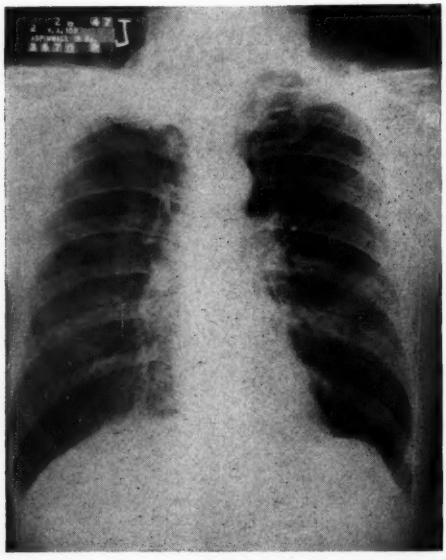


Fig. 3 (Case 10).—H. O. H., aged 48 years. Plombage, April, 1939, closed 1.5 cm. cavity right apex. Clinically arrested. Sputum conversion. February, 1947, no active tuberculosis. Clinically arrested.

CASE 11.—J. C. Age, 44 years. Negro. Steelworker. Symptoms for eight months prior to admission November, 1936, Aspinwall. Hemoptysis frequent. Sputum positive. Wassermann + 4. Bilateral infiltration of both upper lobes as far as second interspace, 2 cm. cavity on right side. Artificial pneumothorax induced on right. Poor collapse. December, 1936, phrenic crush, did not secure a rise in the diaphragm. Plombage May, 1937. Novocain Avertin anesthesia. Two-inch section third rib; 500 Gm. pack. Roentgenogram June, 1937, showed collapse of cavity. Sputum negative. No further hemoptysis. Discharge improved. Readmitted October, 1940, because of hemoptysis. Roentgenogram showed right upper lobe cavity closed, extensive fibrosis in both lungs, a spread of tuberculosis in the left upper lobe. Death May, 1941, from progressive tuberculosis.

CASE 12.—L. R. Salesman. Age, 34 years. Symptoms of tuberculosis, chiefly pleuritic pain, for two years. Admitted to Tuberculosis League Hospital. Roentgenogram showed scattered areas infiltration at right apex and in the third and fourth spaces; on left side soft infiltration in the second, third, and fourth spaces, and a 5 cm. apical cavity. Had carried artificial pneumothorax for over a year with only 30 per cent collapse. Sputum

positive. Plombage, February, 1934. Sodium pentothal Novocain anesthesia. Two-inch section of fourth rib; 400 Gm. pack. Developed *Staphylococcus aureus* wound infection, bronchopneumonia bilateral, and bacteriemia. Paraffin pack removed. Wound Dakinized. Death six days after operation. Autopsy showed no evidence of bronchopleural fistula. Cavity collapsed partially.

CASE 13.—M. S. In 1929 was struck in the right chest. Had hemoptyses for six months at irregular intervals and pain in right chest on exertion. Dec. 27, 1929, developed severe hemoptysis controlled by right phrenic crush. Roentgenogram showed some fibrosis and small areas of infiltration in the right upper lobe. In the next two years still subject to small hemoptyses, and pain in the chest. Dec. 21, 1933, developed very severe bleeding over three days' time. Plombage, Jan. 1, 1934. Novocain anesthesia. Three-inch section of eighth rib in the posterior axillary line; 500 Gm. pack. This controlled the bleeding. Admitted to Tuberculosis League Hospital January, 1935, on account of persistent fatigue, night sweats, and dyspnea on exertion. Roentgenogram showed moderately dense mottling

Fig. 4 (Case 13).—M. S. Paraffin plombage for lower lobe lesion fourteen years previously. Apparently cured.

in the second and third spaces, paraffin pack below the level of the third rib. Only one sputum examination in March, 1935, returned positive for tuberculosis. Subsequent examination showed increased density in the right lung field. Repeated sputum examination proved negative. Hospital care continued at Cresson Sanatorium for one year. Discharged September, 1937. Returned to his native Czechoslovakia to work on farm. Pressed into service in German Labor Battalion for four years. Returned to this country January, 1948, to take up farming. Free from symptoms. Looked to be in perfect physical condition. Roentgenogram showed no evidence of active tuberculosis. Left lung field entirely clear. Dense fibrosis from the third rib to the base of the right lung.

CASE 14.—M. I. C. Age, 44 years. Four-year history bilateral apical tuberculosis. Infiltration in both apices with 2 cm. cavity right apex. Sputum positive. Artificial pneumothorax induced. At the end of four months collapse was poor. Plombage was attempted July, 1937. Avertin Novocain anesthesia. Section two inch, third rib. Line of pleural cleavage could not be obtained. Died of progressive tuberculosis in February, 1938.

CASE 15.—M. S. Female, age, 30 years. Telephone operator. Tuberculosis for eleven years, in which time artificial pneumothorax had been ineffectual, and then had frequent recurrent hemoptysis. Involvement was massive in right apex through the first and second spaces with multiple small cavities. Sputum positive. Plombage January, 1939. Anesthesia sodium pentothal and Novocain. Section one and one-half inches of fourth rib; 375 Gm. pack, securing complete collapse of upper lobe. Patient's condition seemed satisfactory as she left operating room, though cyanosis was noted. Several hours later developed extreme dyspnea, cyanosis, very rapid heart action, and died six hours after operation. Autopsy not granted. It is presumed that the cardiorespiratory failure was induced by too heavy pressure of the pack on the great vessels.

Fig. 5 (Case 16).—E. O. B., aged 25 years. Paraffin plombage fifteen years previously. No pulmonary symptoms. Apparently arrested.

CASE 16.—E. O. B. Female, age, 25 years. Clerk. History of tuberculosis for four years. Bilateral apical infiltration. Cavitation right apex. Positive sputum. Artificial pneumothorax induced in April, 1933. Inefficient. Plombage, November, 1933. Sodium pentothal Novocain anesthesia. Two-inch section fourth rib; 500 Gm. pack. Phrenic crush November, 1935. February, 1936, 2 cm. cavity right lung closed. Tuberculosis left apex arrested. Sputum negative. This patient has remained well. Had an appendectomy, 1938.

Married. Delivered of normal child by cesarean section, 1942. For seven years has taken care of five-room house and enjoyed good health with no pulmonary symptoms. Roentgenogram April, 1948, shows no evidence of active tuberculosis. Cavity closed. Paraffin pack still in place.

CASE 17.—L. L. Age, 22 years. History of tuberculosis two years. Frequent hemoptysis. Roentgenogram showed bilateral tuberculosis both upper lobes. Cavity in right upper lobe 6 cm; left upper, 5 cm; general condition not good. Plombage, left, May, 1943. Cyclopropane Novocain anesthesia undertaken as a forlorn hope. Two inches of third rib removed; 350 Gm. pack. Roentgenogram showed partial closure of the cavity. Plombage, right, July 10, 1943. Novocain and cyclopropane anesthesia 500 Gm. pack. Two inches of fourth rib removed. Following these operations there was no further hemoptysis. Sputum continued profuse and positive. Progressive involvement of both lungs. Death in October, 1944. Neither cavity was completely obliterated. February, 1944, patient commenced to expectorate paraffin in small amounts. Shortly thereafter a bronchopleural fistula developed on the right side, and through this at times small bits of paraffin were extruded. Eventually this fistula closed.

A. *B.*

Fig. 6 (Case 20).—C. B., aged 28 years. *A*, Abscess lung. Before pack, 1935. *B*, Taken March, 1948. No pulmonary symptoms after pack.

CASE 18.—W. W. Miner. Age, 43 years. Admitted Aspinwall, August, 1938, with symptoms of pulmonary suppuration. Bronchoscopy showed no evidence of tumor. In November developed an empyema containing *Staph. aureus* and *Streptococcus hemolyticus.* When empyema had partially cleared several abscesses in the lung were drained. In April, 1939, developed severe hemoptysis which was not controlled by a phrenic crush. May 2, 1939, plombage of right lower lobe. Novocain anesthesia. One and one-half inches of eighth rib removed posterior axillary line. Hemoptysis was not controlled. Death occurred May 13, 1939, from large hemorrhage. Autopsy disclosed bronchiogenic carcinoma of lower lobe bronchus.

CASE 19.—H. S. Age, 41 years. Salesman. 1930, developed a right lobar pneumonia. Following this had persistent cough and purulent sputum in small amount with occasional small hemorrhage due to bronchiectasis. Admitted to Presbyterian Hospital Feb. 26, 1942, on account of severe almost exsanguinating hemorrhage. Phrenic crush and artificial pneumothorax carried out simultaneously. This failed to control bleeding. Plombage, February 28. Novocain anesthesia. Two inches of eighth rib excised in posterior axillary line; 450 Gm. pack, re-enforced with iodoform gauze pack. No further bleeding. Ten days later iodoform gauze removed and one pint turbid sterile fluid evacuated together with several loose pieces of paraffin. Discharged from hospital April 5 with wound healed, free from cough and sputum. Remained well until July, 1947, when he had small hemorrhage and in September a larger one. Then had a long deferred lobectomy by Dr. Kipp at Mercy Hospital and is free from symptoms.

CASE 20.—C. B. Female, housewife. Age, 28 years. Following dental extraction March, 1934, pneumonia and lung abscess developed. Persistent cough and purulent sputum. Hemoptysis began six months later and recurred at frequent intervals. X-ray examination May, 1935, disclosed a 2 cm. cavity near the periphery in the right lower lobe. Plombage, June, 1935. Novocain anesthesia. Two-inch section sixth rib posterior axillary line; 300 Gm. pack. No further hemoptysis. Cavity closed and patient free from symptoms in several months. Has remained well. Roentgenogram March, 1948, showed pack in place. Lung otherwise normal.

RESULTS

At the present time, of the 16 patients in which plombage was completed, 3 are known to be living and well and free from symptoms after a period of eight, thirteen, and fifteen years. One has married and borne a child; another served in the German Army for four years in the last war. Ten patients are known to be dead. Two died in the immediate postoperative period, one of cardiorespiratory failure and the other of *Staph. septicemia.* The other 8 died as a result of progressive tuberculosis. At least 4 of these after the operation showed immediate and substantial clinical improvement with reduction of cough, sputum, gain in weight, and even sputum conversion, only to relapse in a one- to three-year period. Three of the patients have not been traced beyond a three-year period after operation.

Cavities were completely closed as far as one could judge by x-ray findings in 10 cases, were partially closed in four, and presumably not affected in the 2 patients who died soon after operation.

Four cases were known to have developed a bronchopleural fistula because of paraffin spitting. Hemoptysis in 2 of the patients, persistent before operation, was stopped, in 2 others was not controlled. One case developed recurring hemoptysis after operation. Sputum conversion to negative occurred in 8, to plus minus in 3, and was not obtained in five. In 2 cases of conversion, sputum became positive after one year.

As greatly as one would like to believe that plombage is free from complication and without immediate mortality, it is universal experience that there is morbidity and an occasional death directly due to the operation. I have tabulated the complications as reported in four series of cases totaling 186 patients, including my own 16, in Table I:

1. It will be seen that pyogenic infection is the most frequent complication, superficial in 3 instances and deep in six. One of these cases developed a fatal

TABLE I. POSTOPERATIVE COMPLICATIONS

	MC INDOE, STEELE, AND ALEXANDER	HEAD	OTTAVIANO	STEELE	DECKER	TOTAL
Superficial wound infection	3					3
Deep wound infection		1	4		1	6
Septicemia (fatal)					1	1
Extra pleural effusion	2			1		3
Hemorrhage, extra pleural space	2					2
Cold abscess	3					3
Fistulas, bronchopleural	5	3	5	2	4	19
Fistulas, bronchocutaneous			5			5
Fatal lung tear	2					2
Contralateral spread	3	1				4
Paraffin coughed up	1	3	4		4	12
Paraffin removed		1	6		2	9
Transient dyspnea	12					12
Cardio respiratory failure (postoperative)					1	1

CAUSES OF DEATH: POSTOPERATIVE

	MC INDOE, STEELE, AND ALEXANDER	HEAD	BEHRENS	DECKER
Septicemia			3	1
Wound infection		1		
Nontuberculous pneumonia		1		
Cardiorespiratory	1			1
Lung tear	2			
Cold abscess	2			
Operation	2			
Tuberculous enteritis		1		

Staph. septicemia. In a small series incompletely reported by Behrens there were 3 deaths from septicemia.

2. A tuberculous abscess developed about the pack in 3 cases.

3. Fistulas developed, bronchopleural in 19 and bronchocutaneous in five. Eleven patients coughed up paraffin after a period of several weeks to months. The handling of these cases presents somewhat of an individual problem. It may be necessary to remove the pack. Others will stop coughing up paraffin spontaneously. I believe the majority will tolerate the pack for years without unfavorable reaction. Whether this will be true of the newer pack materials, Lucite and fiberwool, remains to be demonstrated.

4. Effusions of size requiring tapping occurred in 3, and a sizable hemorrhage in the cavity in 2 patients.

5. Fatal lung tear happened in 2 cases.

6. Cardiorespiratory symptoms were reported as severe dyspnea in twelve cases by John Alexander. Circulatory failure was responsible for death in two cases.

7. Spread of tuberculosis in the contralateral, or same lung, are hard to evaluate in terms of being due to the operation, since they may represent a

TABLE II

	MC INDOE, STEELE, AND ALEXANDER	HEAD	OTTAVIANO	STEELE	BEHRENS	DECKER	TOTAL
Year of report	1939	1937	1941	1946	1933	1948	
Time of follow-up	2 to 5 yr.	Several			1 to 3 yr.	8 to 15 yr.	
Apparently cured	31 (37.8%)			27 (69%)	22 (57%)	3 (18.7%)	83 (31%)
Apparently arrested	23 (28.1%)		27 (60%)				50 (19%)
Quiescent	9 (11%)		12 (26.7%)	2 (5%)			23 (8.7%)
Improved	4 (4.8%)	1 (47.7%)			7 (19%)		12 (32%)
Unimproved	2 (2.4%)	4 (9%)			4 (10.8%)		10 (3.8%)
Dead	7 (8.6%)	3 (6.8%)	6 (13.3%)	5 (13%)	5 (13.2%)	10 (62.5%)	36 (13.6%)
Unevaluated		16 Sputum negative		5 (13%)			21 (8.9%)
Untraced	6 (7.3%)					3 (18.7%)	9 (3.5%)
Total	82	44	45	39	38	16	264
Sputum conversion	67%	36.4%	75%	75%		50%	61%
Cavity closure	68.9%					62.5%	65.2%

normal progress of the disease. In 3 cases at least the spread was thought to be definitely a consequence of the operation.

Reports in the literature of the end results to the patient after paraffin pack are rather meager and incomplete, and cover as a rule only short follow-up periods seldom beyond a year or two. Five reports are tabulated in Table II. Also, the effect of plombage upon cavity closure is infrequently recorded. McIndoe, Steele, and Alexander, however, analyzed the fate of cavities in their 82 cases. They concluded that the closure of cavities less than 2 cm. in diameter will occur in more than 50 per cent of cases, and of cavities more than 2 cm. in diameter in less than 50 per cent; if above 4 cm. in diameter, closure of only 33 per cent may be expected. Supraclavicular cavities have a two-to-one chance and infraclavicular a two-to-three chance of closure, very fibrous cavities less than 50 per cent, honeycombed only 50 per cent. In my own series only 2 cavities out of 14 were larger than 4 cm. and neither of these was closed; 5 out of 6 where the diameter was 1 to 2 cm. were closed; and 5 out of 7 where the diameter was 2 to 4 cm. were closed. In 2 cases only was the cavity supraclavicular, and these were both closed.

Of the 264 cases reported in the table, 31 per cent were regarded as apparently cured, 27.5 per cent in a state of arrest, 12 per cent improved, while 17.5 per cent were unimproved or dead. About 60 per cent then are credited with having benefited markedly from the plombage. Even though with the passage of time, the percentage of good results lessens appreciably, the statistics seem to demonstrate the real value of the operation and justify the confidence of the surgeons who have practiced it.

I have had occasion to place a paraffin pack in 3 nontuberculous patients where hemoptysis was alarming and might easily have been fatal. The first patient had a small abscess, bleeding persistently, located in the upper outer portion of the lower lobe. The resection of the lobe seemed to be too major a procedure and drainage would have required two stages and injured much pulmonary tissue. The second patient had severe bleeding from a lower lobe bronchiectasis, which was not controlled by a phrenic crush and artificial pneumothorax. A segmental resection was not justified on account of the patient's condition. The third patient was known to have pulmonary suppuration, but found at autopsy to have carcinoma of the lung as a primary lesion. In only this case was bleeding not controlled.

I am not one to advocate plombage as a means of treating pulmonary suppuration, when segmental resection or lobectomy can be performed. Occasionally, however, plombage can be of service in healing a small abscess or in tiding over a critical situation until a more favorable time comes for extirpation of the diseased lung.

CONCLUSION

In evaluation of the operation of paraffin plombage in the light of comparatively small experience reported, I believe that this treatment should have a definite place in collapse therapy, and that it is entitled to wider use. It should not be in competition with any other method, particularly thoracoplasty.

When one follows the indications closely, cavity closure and sputum conversion may be expected in one-half of the cases. Many cases will go on to arrest and recovery directly as the result of the plombage. Others are put in condition to survive a secondary thoracoplasty and then go on to recovery. A sizable group will register general clinical improvement for a prolonged period, even though they ultimately succumb to the disease.

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CHONDROSARCOMA OF THE POSTERIOR MEDIASTINUM WITH HOURGLASS INVOLVEMENT OF THE SPINAL CANAL: RESECTION AND RECOVERY

Report of a Case

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THE unusual occurrence of a posterior mediastinal chondrosarcoma with hourglass involvement of the spinal canal as well as invasion of the lung, ribs, and thoracic vertebrae has been the chief reason for reporting the following case.

Case Report (No. 107001).—A. L. was a 40-year-old white veteran, a farmer, admitted to this hospital on Aug. 20, 1948, because of numbness of the legs and inability to walk for the past three weeks. Eight months prior to admission he had noted for the first time a recurring intermittent "knife-like" pain in the left side of the back "at the level of the heart." About one month prior to entry he had noted occasional numbness of the soles of the feet; three weeks before admission this symptom had suddenly increased to numbness of the lower portion of the body below the waist, associated with inability to walk because of weakness of the legs. He had lost about fifteen pounds during the three months preceding his admission. On the day of admission he was unable to void for the first time.

A survey of his past history revealed that in 1944, while serving with the Army in Burma, a tree fell across his back causing him to be hospitalized for sixty-five days. There were no fractures or neurologic disturbances occasioned by this injury however, and the exact nature and extent of the injury was not known. The system review was otherwise noncontributory.

Physical examination revealed a well-developed, well-nourished man lying flat in bed in no apparent distress. The temperature was 98.4° F., the pulse rate 88 per minute, the respirations 20 per minute, and the blood pressure was 134 mm. systolic and 84 mm. diastolic in both arms. The head and neck were normal. The eye examination revealed pupils equal in size and regular in outline; the light and accommodation reflexes were normal as were the extraocular movements; the fundi were normal.

Examination of the chest showed a slight bulge with no distinct outline in the left midthoracic paravertebral area which was moderately tender to deep pressure. The heart and lungs presented no abnormal findings.

Neurologic evaluation revealed a marked weakness of both lower limbs. There was a loss of cutaneous sensation below the level of the seventh dorsal segment on the right and below the sixth dorsal segment on the left. The knee and ankle jerks were exaggerated bilaterally, and the Babinski reflexes were positive bilaterally. There was absence of the position sense in the toes of both feet. A study of the spinal fluid by means of lumbar puncture revealed a clear fluid with a complete subarachnoid block. The initial pressure was 190 mm. of water.

The significant findings on roentgenologic examination were the presence of a round circumscribed mass in the posterior left chest and erosion of the left pedicles of the adjacent sixth and seventh thoracic vertebrae (Figs. 1 and 2). Myelographic studies with Pantopaque revealed a spinal cord compression at the level of the sixth and seventh vertebrae.

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Neurosurgical exploration was decided upon as the first step in handling this patient. Accordingly, on Aug. 7, 1948, a spinal cord decompression was performed* by means of a left hemilaminectomy of the sixth and seventh thoracic vertebrae and a portion of an intraspinal, extradural tumor mass which was present in this area was removed. This tumor was reported by the pathologist to be a chondrosarcoma.

Following the neurosurgical operation the patient exhibited a marked improvement in general neurologic condition, and gradually regained the ability to walk. There was also a marked return of the sensory impairment previously noted. He continued unable to void, however, so that an indwelling catheter was utilized along with intermittent bladder irrigations and tidal drainage. Because of the patient's improvement and in spite of the invasive character of the tumor he was transferred to the Thoracic Surgical Service on Sept. 16, 1948, for further surgical therapy.

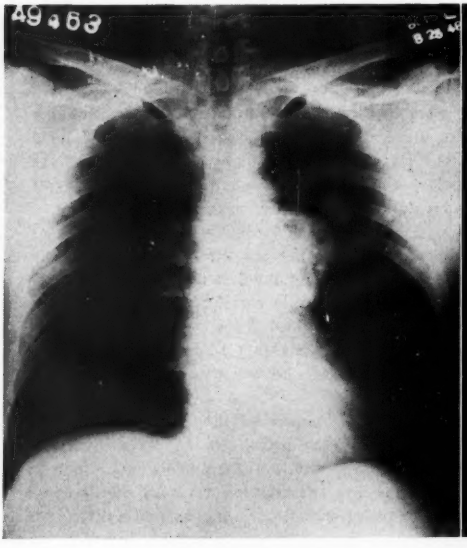

Fig. 1.

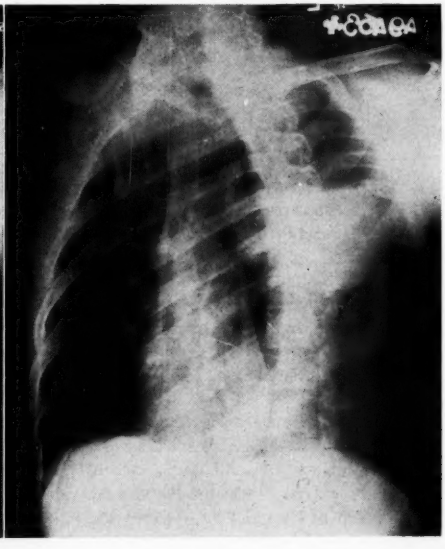

Fig. 2.

Fig. 1.—Roentgenogram showing round circumscribed tumor mass in the left paravertebral region.

Fig. 2.—Roentgenogram, left anterior oblique view, showing rounded sharply circumscribed tumor mass in the left paravertebral area with erosion of the vertebral end of the seventh rib.

A left thoracotomy was performed under general endotracheal anesthesia on Sept. 21, 1948. A posterolateral segment of the seventh rib was removed subperiosteally to about three inches from the angle of the rib. This rib appeared to be involved in the tumor mass as far laterally as the angle. Posterolateral segments of the eighth and sixth ribs were then removed in a similar manner as far as the rib necks posteriorly. The tumor could be seen to be infiltrating the apex of the lower lobe so that the pleural space was then entered through an incision in the bed of the seventh rib.

A segmental resection of the apex of the lower lobe was then accomplished leaving the involved lung and pleura attached to the mass. This procedure allowed mobilization and retraction of the lung so that the mediastinum could be visualized and approached.

The tumor was found to be a round, firm mass, about 10 cm. in diameter, apparently well contained except where it had involved the lung and seventh rib and at its points of attachment to the vertebral structures. It was apparently eroding and growing through

*By Dr. J. A. Mufson, the neurosurgical consultant.

Fig. 3.

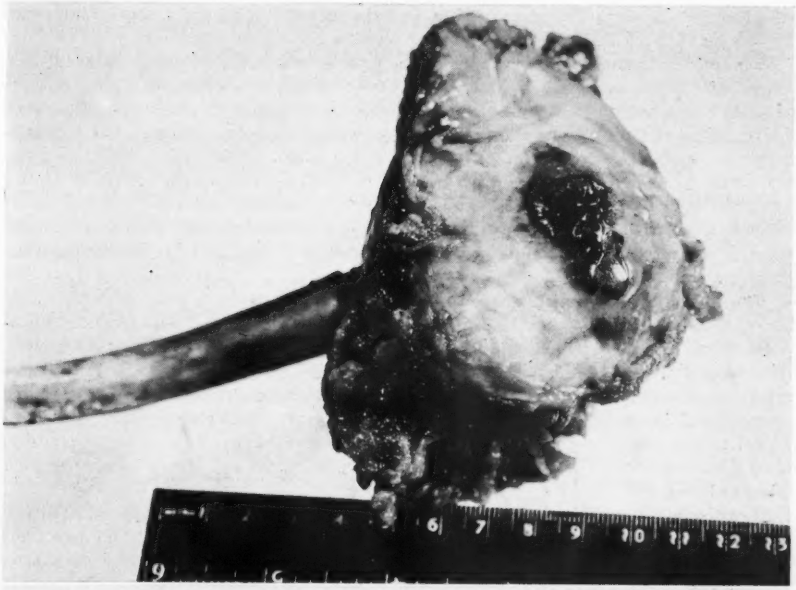

Fig. 4.

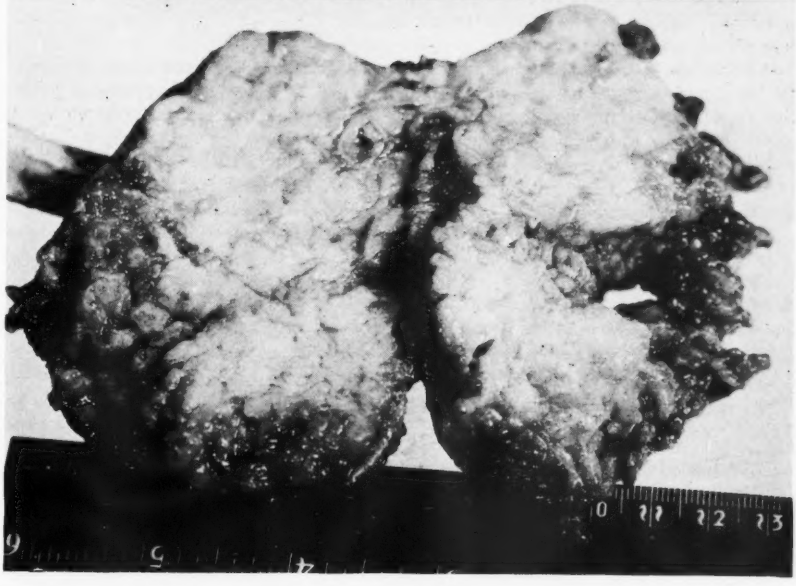

Fig. 3.—Tumor mass with involved lung tissue removed from left posterior mediastinum.
Fig. 4.—Same as Fig. 3, seen on cut section.

the lateral foramen between the sixth and seventh vertebrae, but it also seemed adherent to the sixth and eighth rib heads, the remaining lamina, pedicle, and a small lateral portion of the body of the sixth thoracic vertebra, and the intervertebral and posterior intercostal structures between the sixth and eighth thoracic vertebrae.

The tumor was removed en bloc excising the involved rib heads, vertebral lamina, pedicles, and portions of the vertebral body, and intervertebral and intercostal structures with the tumor. It was necessary to excise a portion of the dura to remove the tumor, and the pedicles and left lamina of the sixth and eighth vertebrae were resected to secure adequate visualization and removal of the tumor extending within the spinal canal. The dural fistula thus created was repaired by the use of Gelfoam film. The chest wall was then reconstructed in layers as far as possible with interrupted cotton sutures. The large pleurointercostal defect was covered by a sheet of Gelfoam film sutured to the edge of the remaining parietal pleura, and this was covered by the posterior chest wall and back muscles, and skin, and the wound was closed without drainage.

The pathologic description was as follows.* The gross specimen consisted of a roughly spherical mass measuring 10 cm. in its greatest diameter (Figs. 3 and 4). Over the surface was a smooth, shiny, gray-pink capsule similar to pleura. Attached to the external surface of this capsule was an area of mottled, gray-black pleura and lung substance. This capsule covered approximately one-half of the spherical mass. The opposite hemisphere was irregular in contour and in areas it was honeycombed in appearance. In areas there were pieces of dark red muscle protruding from the surface. Numerous tendinous bands coursed across the surface. Incorporated in this mass was a large portion of rib and several smaller segments of bone and ribs.

The tissue cut with marked resistance. The cut surface in portions was soft and semi-gelatinous in consistency. In other areas it was pink and gray and translucent in appearance.

The microscopic section showed cartilaginous tissue invading bone and bone marrow. There were some areas with necrotic cells while in others large oval-shaped, vesicular chondroblasts within lacunae were seen. The matrix appeared that of immature cartilage and there was an abundance of hyaline material.

The patient's postoperative course was satisfactory although complicated by a recurring partial hydropneumothorax which required aspiration of 200 to 400 c.c. of air and fluid on six occasions. Intensive physiotherapy begun before the operation was restarted on the day of operation directed at breathing exercises, weight-resistive exercises of the legs, and walking training. This therapy was continued daily up to his discharge from the hospital.

On Oct. 5, 1948, the indwelling catheter was removed and spontaneous normal micturition began that day. No significant residual urine was found on rechecking the bladder urine.

The patient demonstrated a gradual progressive improvement in walking and in the respiratory motions of the left chest. On Oct. 8, 1948, the roentgenograms of the chest showed complete re-aeration of the left lung with slight pleural thickening at the left base and no significant pneumothorax. He was discharged from the hospital on Nov. 15, 1948, complaining only of some residual soreness of the back, but as we learned later he was able to go deer hunting two days after he left the hospital.

The patient returned to this hospital for evaluation on Dec. 15, 1948, and examination revealed further progress in walking; his posture was normal, and the wound was well healed. Roentgenograms of the chest showed the postoperative changes incident to the rib and partial vertebral resections, but no other abnormalities were noted.

He returned again on March 14, 1949, for further follow-up study and was found to be in excellent health and able to get around well. Repeat roentgenograms of the chest were negative other than the changes incident to surgery mentioned previously.

DISCUSSION

The rarity of chondrosarcomas occurring in the posterior mediastinum and the even more infrequent reports of these lesions causing hourglass or dumbbell

*Joseph M. Lubitz, pathologist.

types of tumors are apparent in a survey of the literature.[1-14] In a group of cases reviewed at the Mayo Clinic, Uhrich[14] found that among 42 malignant mediastinal tumors, from which were excluded lymphomatous tumors and metastatic carcinomas, there were 6 chondrosarcomas. Heuer and Andrus[11] collected 14 cases of chondromatous tumors involving the mediastinum from the literature from 1926 to 1940; in addition, they reported 4 cases of this type from their own series of mediastinal tumors. Two of the tumors in their report involved the posterior mediastinum and one was an hourglass type of tumor causing cord compression within the spinal canal. Heuer[10] had previously described a case reported by Elsberg of a chondrosarcoma of the posterior mediastinum involving the spinal cord.

The name of hourglass tumor has been applied to those tumors occurring along the spinal column and growing on both sides of an intervertebral foramen or through the space between two vertebral laminae. The tumor has derived its descriptive terminology from the constricted portion of the tumor extending through the intervertebral foramen or the interlaminar space. The group of these lesions in which the tumor we are reporting can be classed is that involving the posterior mediastinum as well as the spinal canal. The most common pathologic type of tumor occurring in this double location has been the neurofibroma,[2, 10, 11, 12, 14] although a large variety of pathologic lesions have been reported as causing this type of tumor. Among the various histologic types reported have been the neuromas, fibromas, ganglioneuromas, lipomas, chondromas, fibrosarcomas, spongioblastomas, liomyomas, endotheliomas, neuroblastomas, and hemangioendotheliomas.

The specific origin of the tumor in the case herein reported is difficult to assess, but the abundance of ligaments, fascia, periosteum, and cartilage in the articular surfaces of the ribs and vertebrae in the posterior mediastinum provide sufficient possible sources of development of tumors of this type. The similarity of the chondrosarcomas to osteogenic sarcomas has also raised the question as to whether these tumors might not be osteogenic in origin. The significance of the previous trauma elicited in the history of this patient is probably doubtful, but it is interesting in view of the frequency with which previous trauma is commonly revealed in the history of patients developing osteogenic sarcomas in other parts of the body.

The histology of the chondrosarcoma in this case was characteried by an atypical chondral tissue with an abundant hyaline matrix invading bone and bone marrow. There were numerous areas of necrosis and cystic degeneration. The apparent paucity of myxomatous tissue has been the chief feature not coinciding with most of the pathologic descriptions of those tumors appearing in the literature.

The prognosis in this case is of course uncertain but the improvement gained in the first six months postoperatively has been encouraging.

SUMMARY

A case is reported of a 40-year-old white man presenting a chondrosarcoma of the posterior mediastinum producing an hourglass type of tumor with spinal

cord compression causing lower extremity paralysis. There was also invasion of the pleura, lung, ribs, and adjacent thoracic vertebrae.

The tumor was removed through a posterolateral thoracotomy following an initial laminectomy and spinal cord decompression, with immediate recovery and clinical improvement.

ADDENDUM

The patient was examined thoroughly on Dec. 16, 1949. He showed a remarkable clinical improvement and there was no evidence clinically or radiologically of a recurrence of the tumor.

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INLYING RUBBER TUBE AFTER ESOPHAGEAL ANASTOMOSIS

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THIS study was prompted by the death of a 78-year-old colored man on the third day after resection of a carcinoma of the middle third of the esophagus. No tube with intragastric suction had been employed; the vagotomized, intrathoracic stomach apparently gradually accumulated large quantities of fluid. Regurgitation and aspiration of this material resulted in the patient drowning in gastric secretions, as found at autopsy. Had intragastric suction been used, a favorable outcome might have resulted.

In the literature, varying opinions are found regarding the relative values or dangers of an inlying tube after esophagoesophageal and esophagogastric anastomosis. Those experienced in the treatment of congenital atresia of the esophagus with or without tracheoesophageal fistula generally oppose the use of a tube. Haight and Towsley[1] felt that the catheter increased pharyngeal secretions, that it tended to obstruct the esophagus at the anastomosis allowing accumulation of secretion with spill into the trachea, and that healing was more satisfactory if a foreign body was not present within the esophageal lumen. Humphreys[2] believed the tube stimulated sucking and increased oral secretions. Ladd and Swenson[3] did not use a tube as this "diminishes the chance of respiratory infection and infection of the anastomosis." Gross[4] omitted the tube because then "The esophagus can be given the best chance for healing during the early postoperative period." With reference to esophageal resection for carcinoma, Garlock[5] stated, "The situation at the suture line is precarious enough without adding the danger of pressure necrosis from a Levin tube." Rankin and Hurt[6] left a tube down four to five days, and Griswold[7] for seventy-two hours. Nagel and Menke[8] kept the tube down about five days "to prevent vomiting which would cause strain on the suture line." Thorek[9] never hesitated to employ a tube as he believed "If the caliber of the tube over which the anastomosis is made is smaller than the stoma through which it passes, pressure is avoided and the blood supply is not impaired."

In order to study this problem, the following experiment was carried out.

METHOD

Mongrel dogs weighing 8 to 16 pounds were used. Thoracotomy on the left was performed under Nembutal anesthesia, with endotracheal intubation. The lower third of the esophagus was freed up, care being taken to preserve the vagus nerves and as much of the blood supply as possible. The esophagus was divided transversely. An anastomosis was carried out using two layers of interrupted 00000 silk sutures, one layer in the mucosa and submucosa, and the second layer in the muscular coats. The esophagus was handled carefully and the sutures placed meticulously. Before the chest was closed, an assistant passed a rubber tube down the esophagus into the stomach. After the operation was completed, the tube was wired to the lower molars on one side and the excess tube cut off. Most of the tubes were regurgitated and chewed off, so that the duration given in the results for the time the tube was in place indicates the time of the last examination when the tube was known to be intact. The exceptions were the three tubes removed at ninety-six hours.

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TABLE I. SUMMARY OF RESULTS OF HEALING IN ESOPHAGEAL ANASTOMOSIS WITH INLYING RUBBER TUBE

NUMBER	HOURS TUBE IN PLACE	TIME-OPERATION TO AUTOPSY (DAYS)	GROSS FINDINGS	MICROSCOPIC FINDINGS			COMMENT
				MUCOSA	SUBMUCOSA	MUSCULAR	
1	No tube	6	Slight mucosal separation	Small ulcer	Moderate acute inflammation	Healing well	
2	No tube	7	Healing well*	Healing well	Minimal chronic inflammation	Healing well	
3	48†	2	Healing well		Not studied‡		Died, pneumonia
4	48†	2	Healing well	Small ulcer	Moderate chronic inflammation	Moderate chronic inflammation	Died, pneumonia
5	48†	2	Healing well		Not studied‡		Died, pneumonia
6	24	6	Healing well	Healing well	Moderate chronic inflammation	Healing well	
7	24	6	Healing well	Healing well	Healing well	Healing well	
8	72	9	Healing well	Healing well	Healing well	Healing well	
9	96	6	Healing well	Small ulcer	Moderate chronic inflammation	Healing well	
10	96	6	Healing well	Healing well	Healing well	Slight chronic inflammation	
11	48	42	Well healed*	Well healed	Well healed	Well healed	Died, pneumonia
12	No tube	90	Well healed	Well healed	Well healed	Well healed	No stricture
13	24	90	Well healed	Well healed	Well healed	Well healed	No stricture
14	24	90	Well healed	Well healed	Well healed	Well healed	No stricture
15	30	90	Well healed	Well healed	Well healed	Well healed	No stricture
16	72	90	Well healed	Well healed	Well healed	Well healed	No stricture
17	96	90	Well healed	Well healed	Slight chronic inflammation	Well healed	No stricture

*Healing well indicates fibroblastic proliferation; well healed indicates mature scar tissue.
†Large tube.
‡Too autolyzed.

The dogs were allowed water for the first two days, or until the tube was out. Soft food, including a protein hydrolysate, was then given until the seventh or eighth day when they received the regular kennel rations.

With the variations as indicated in Table I, the esophagus was removed in six or ninety days for gross and microscopic study.

RESULTS

The results are recorded in Table I. Three dogs had large tubes (1 cm. external diameter), and all died on the second day after operation. Each had marked swallowing effort and profuse salivation in the same manner as the animals of Dragstedt and Mullenix[10] which were subjected to acute esophageal obstruction, and died of aspiration pneumonia in one to four days.

The tube used in the other animals was a No. 14 French Levin tube. From the table, it is readily apparent that no interference with healing occurred as a result of the tube in so far as could be determined by gross and microscopic study.

DISCUSSION

In infants who have had an esophageal anastomosis, the objections to the use of a tube would seem valid, because of the possibility of increasing the chances of excessive oral secretions and consequent aspiration pneumonia. In the adult, however, this should be less prone to occur as the patient should be able to expectorate or swallow such secretion. Resections for carcinoma of the esophagus usually involve interruption of the vagus nerves, and the vagotomized stomach may be expected to retain considerable fluid. If the inlying rubber tube does not interfere with healing of the anastomosis, intragastric suction should be a valuable supplement in the postoperative care of these patients.

Admittedly, the solution of problems related to the esophagus of man may not be answered without reservation on the basis of experiments in dogs, since the esophagus does differ in dog and in man.

CONCLUSION

Under the conditions of this experiment, an inlying rubber tube, No. 14 French in size, does not interfere with the healing of an esophageal anastomosis in dogs.

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THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

THIRTIETH ANNUAL MEETING
APRIL 15, 16, 17, AND 18, 1950, HOTEL COSMOPOLITAN
DENVER, COLO.

PROGRAM

Saturday Morning, April 15, 1950

9:00 A.M. BUSINESS MEETING

9:30 A.M. SCIENTIFIC SESSION

1. **Intrathoracic Neurogenic Tumors**
   J. T. Godwin (by invitation), W. L. Watson, J. Pool, and W. Cahan (by invitation)
2. **Tumors of the Thymus**
   W. D. Seybold, John R. McDonald, O. T. Clagett, and C. A. Good (by invitation)
3. **Treatment of Carcinoma of the Lung Associated With Malignant Tumors Primary in Other Sites; Report of Eight Cases**
   William G. Cahan (by invitation), Frank S. Butler (by invitation), William L. Watson, and John L. Pool
4. **The Surgical Management of Carcinoma of the Lung**
   E. D. Churchill, R. H. Sweet, L. Soutter, and J. G. Scannell
5. **A Study of Pulmonary Hemodynamics During Pneumonectomy**
   Harvey J. Mendelsohn (by invitation), Henry A. Zimmerman, and Arthur Adelman

Saturday Afternoon, April 15, 1950

2:00 P.M. SCIENTIFIC SESSION

6. **Conservative Management of Empyema Following Total Pneumonectomy**
   Edward M. Kent
7. **The Utilization of Streptokinase-Streptodornase in: (1) A Patient With Hemopneumothorax and (2) a Patient With Postpneumonectomy Sanguineous Coagulum**
   C. Thomas Read (by invitation), and Frank B. Berry
8. **Pulmonary Paraffinoma (Lipoid Pneumonia), A Critical Study**
   Thomas H. Burford and Ralph Berg (by invitation)
9. **Surgery in Pulmonary Coccidioidomycosis—Preliminary Report of Twenty-five Cases**
   Bert H. Cotton and J. W. Birsner (by invitation)
10. **Pectus Excavatum—Management of a Case With Severe Cardiopulmonary Disability With Pre- and Postoperative Angiocardiographic Studies**
    Ralph A. Dorner, Philip G. Keil (by invitation), and Donald J. Schissel (by invitation)

7:00 P.M. COCKTAIL PARTY—HOTEL COSMOPOLITAN

8:00 P.M. BANQUET—HOTEL COSMOPOLITAN
DANCING

Monday Morning, April 17, 1950

9:00 A.M. SCIENTIFIC SESSION

11. **Studies With Arteriovenous Fistulas. I. Response of the Normally Innervated and Denervated Heart to Occlusion of the Fistula**
    H. B. Shumacker,, Jr., L. W. Freeman (by invitation), and Leo Radigan (by invitation)

12. **Experimental Attempts at the Surgical Relief of Aortic Stenosis**
Charles P. Bailey, Robert P. Glover, Thomas J. E. O'Neill (by invitation), and Hector P. Redondo Ramirez (by invitation)
13. **The Experimental Creation and Closure of Auricular Septal Defects**
Henry Swan, George Maresh (by invitation), Marvin E. Johnson, and George Warner
14. **A Physiological Evaluation of Vagus Section for Bronchial Asthma**
Karl P. Klassen, Douglas R. Morton (by invitation), and George M. Curtis
15. **Therapeutic Status of Pulmonary Autonomic Nerve Surgery**
Osler A. Abbott, William A. Hopkins (by invitation), and Paul H. Guilfoil
16. **The Surgical Treatment of Intractable Asthma**
Brian Blades, Edward J. Beattie, Jr., and William S. Elias (by invitation)

Monday Afternoon, April 17, 1950

2:00 P.M. EXECUTIVE SESSION

3:00 P.M. SCIENTIFIC SESSION

Address of the President—Edward J. O'Brien

17. **The Experimental Use of Homogenous Tracheal Transplants**
Truxton D. Jackson (by invitation), Edward J. O'Brien, William Tuttle, and John Meyer (by invitation)
18. **Resection of the Trachea and Bronchi—An Experimental Study**
Max G. Carter (by invitation) and John W. Strieder
19. **Further Experiences With Dermal Grafts for Healed Tuberculous Stenosis of the Bronchi and Trachea**
Paul W. Gebauer

Tuesday Morning, April 18, 1950

9:00 A.M. SCIENTIFIC SESSION

20. **Congenital Atresia of the Esophagus With or Without Tracheo-esophageal Fistula**
Willis J. Potts
21. **Reconstruction of Esophagus**
Ross Robertson and S. T. R. Sarjeant (by invitation)
22. **Use of the Burns' Valve as a Simple Respirator for Intrathoracic Surgery in the Dog**
Joseph T. Dameron and David G. Greene (by invitation)
23. **The Development of and Certain Clinical Applications for a Portable Mass Spectrometer**
Fletcher A. Miller, A. O. C. Nier, Allan Hemingway, Ralph T. Knight, E. B. Brown (by invitation), and Richard L. Varco
24. **The Surgical Treatment of Giant Emphysematous Blebs and Pulmonary Tension Cysts**
David J. Dugan and Paul C. Samson
25. **Experimental Tuberculosis. Effects of Ligation of Pulmonary Arteries on Tuberculosis in Monkeys**
H. William Scott, Jr. (by invitation), C. Rollins Hanlon, and Byron J. Olson (by invitation)

Tuesday Afternoon, April 18, 1950

2:00 P.M. SCIENTIFIC SESSION

26. **Pulmonary Function Before and After Extrapleural Pneumothorax**
Edward A. Gaensler (by invitation), and John W. Strieder

27. **Summary of Pulmonary Tuberculomas, Pathogenesis, Diagnosis and Management**
    Gordon J. Culver (by invitation), Joseph P. Concannon (by invitation), and Joseph E. Macmanus
28. **One-Stage Thoracoplasty for Pulmonary Tuberculosis**
    R. C. Laird and C. E. Lindenfield (by invitation)
29. **Further Experiences With Segmental Resection in Pulmonary Tuberculosis**
    J. Maxwell Chamberlain and Robert Klopstock (by invitation)
30. **Resection in the Treatment of Pulmonary Tuberculosis**
    William M. Tuttle, E. J. O'Brien, J. Claude Day, Foster Hampton, Jr. (by invitation), and Truxton L. Jackson, M.D.
31. **Pulmonary Resection in Pulmonary Tuberculosis**
    A. Himmelstein, Frank B. Berry, and C. T. Read (by invitation)

Papers to Be Read by Title

1. **Temporary Extrafascial Lucite Plombage and Thoracoplasty**
   Elliott Michelson, George W. Wright, and Bernard J. Ryan (by invitation)
2. **Studies in Esophageal Replacement—Influence of Staging of Ligation of Mesenteric Vessels Upon Collateral Blood Supply of Intestinal Segments Freed for Transplantation**
   H. B. Shumacker, Jr., and J. S. Battersby (by invitation)
3. **Further Experiences With the Surgical Treatment of Mitral Stenosis by Commissurotomy**
   Thomas J. E. O'Neill (by invitation), Robert P. Glover, Charles P. Bailey, and Hector P. Redondo Ramirez (by invitation)
4. **Bronchography as an Aid in Surgical Planning in the Treatment of Pulmonary Tuberculosis**
   Joseph Gordon